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THE TECH ENGINEERING NEWS

MEMBER OF THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

13

VOL. V. NO. 1

APRIL, 1924

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FIGHTING A FOREST FIRE

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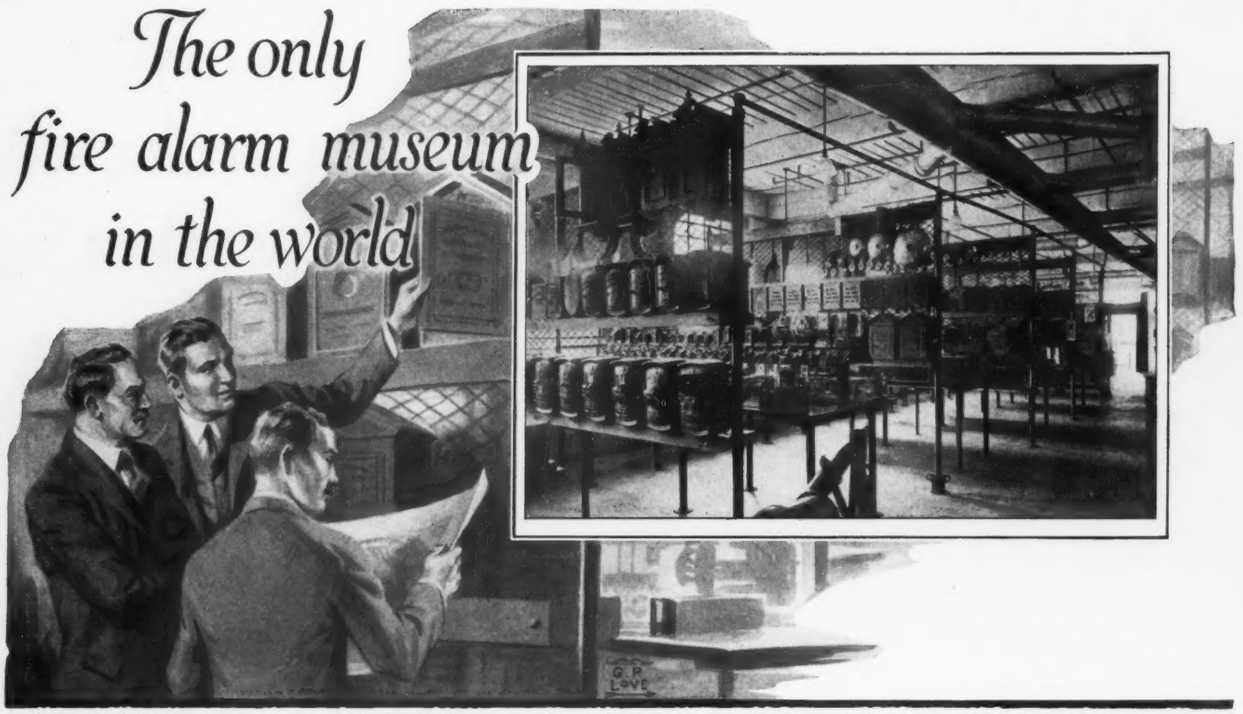

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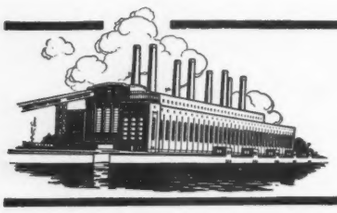

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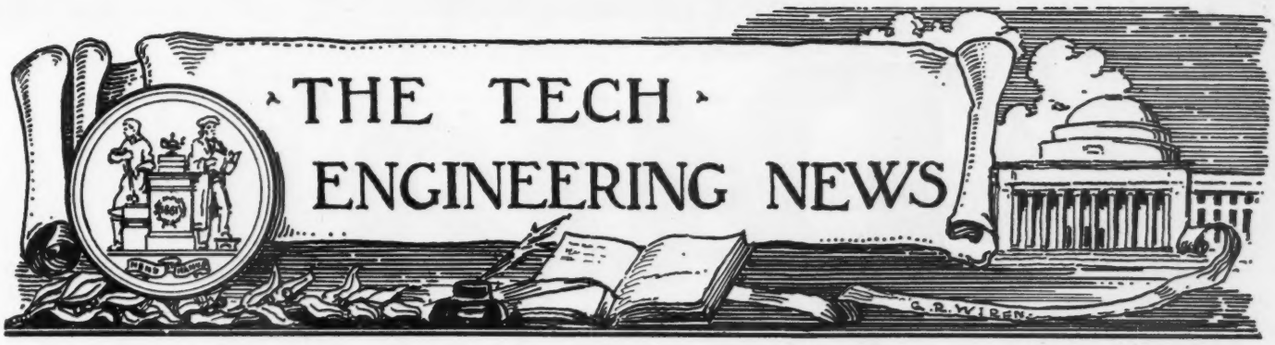

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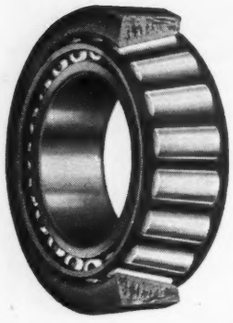

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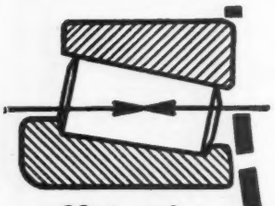
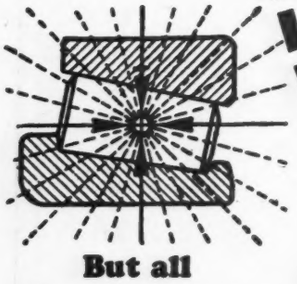


Not only Thrust Loads



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THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME V APRIL, 1924 NUMBER 1

THE SCIENTIFIC MIND

By V. E. HILLMAN

Director of Research, Crampton & Knowles, Worcester, Massachusetts

THE predominant feature of the scientifically trained mind is its ability to associate cause with effect. It is not content with the knowledge and application of facts, but it seeks the reason therefor. It is continually in a state of unrest, turmoil, irritation. Moreover, it manifests a natural inclination and a willingness to know the reason "why." There is an old adage, which says: "Knowing the whys of things makes men wise."

The intellect which has been made the target of systematic knowledge is eager to find out the facts of the case; it searches for truth; it correlates the data available; its reasoning powers are deep-seated; it is analytical; it separates the chaff from the wheat.

The man who has been intimately associated with the sciences, holds his mind open on all vital questions. He refrains from entertaining "half-baked" ideas, and from jumping to conclusions until the entire set of circumstances has been presented to him. A case in point is the railroad strike. Very few business men knew the underlying causes and the dominant reasons which caused the walk-out. Still they formed an opinion from a superficial knowledge of the facts as they appeared in the daily press.

The scientific mind is not satisfied with meager information. It sizes up the problem. It takes a broader perspective of the situation. It realizes the sources of error in life, the fallibility of the intellect, the frailties of human nature. It suspends judgment in the presence of exciting ideas. It is well disciplined. It takes a philosophical view of current problems. It is imaginative; it possesses a greater power of assimilation. It can form hypotheses to good advantage. Briefly, it is the mind which is best adapted for industrial life.

Scientifically trained men come to an executive with a decision — not for a decision. They are keen observers of the inexorable laws of nature. Their minds are rife with practical judgment. Thoroughness characterizes their actions. "Any old thing" won't do.

The sciences have a cultural value and they are used as a vehicle for training a man to notice what he sees. It is well recognized that many of us see but we do not observe. A guide walking through a forest will observe broken twigs, and he will pay particular attention to the moss and lichens on the north side of the trees. He will note the fluttering of the birds which indicates the presence of human beings or danger. In this sense, he has a scientific mind.

A German professor was wont to tell the following story to a group of medical students. He told them that two traits would help them in their professional life, namely: that they should learn to overcome their repugnance to nauseating tastes, and that they should cultivate a habit of observation. To illustrate his point, he dipped his finger into a beaker of quinine and tasted it. He told the class to do likewise, whereupon, each student followed his example. After the conclusion of the experiment, he said, "You have acquired one of the traits which will be of value to the physician, but your power of observation is deficient. None of you observed that I dipped my index finger into the quinine, and tasted the middle finger." There is no doubt but that the professor succeeded in impressing the students with the value of observation.

It is not to be construed, however, that the study of the sciences is the only manner in which an analytical mind may be acquired. An intimate knowledge of the languages, philosophy and the classics will also develop the power of observance, challenge and conclusion. The ideal man is the one who has combined two educations, namely: cultural and scientific. On the other hand, the man who has been educated exclusively in the sciences, will always find a berth in industry in as much as he will yield an immediate return on the investment, but he is likely to be considered a second choice if both types of candidates are seeking a position.

The Massachusetts Institute of Technology strives to develop the ideal man. A former president of this institution said that his school throws her arms widest in welcome to the man who comes up to her walls with his A.B. degree, namely, cultural studies first. After a student has received a liberal education, the scientific training may be super-added.

It is a well recognized fact that men who are eminent in science and men who are pioneers in certain fields of research are those who spend their earlier years in studying the classics. Steinmetz particularly endorses this viewpoint. He contends that the study of Greek affords the student a clearer insight into electrical phenomena, broader vistas, and a keener appreciation of details.

The writer knows of a physician who attributes his extraordinary will-power and his ability to overcome mental inertia, to the study of Xenophon, Plato and Hecuba. The doctor often recites the story of how he remained in the college laboratory one dark, rainy, dismal afternoon and dissected a body while his classmates went to a theater, a foot-ball game or attended some other form of amusement. In later years, the doctor said that he would not have pulled the corpse from the pickling vat on that dreary day if it were not for the mental discipline which he received in the study of Greek.

After all, the value of education is rated by its objective, i.e., purpose. The student should ask himself this question: "What am I being educated for — the practical pursuits of life, or an idealistic career?" If the former question is answered in the affirmative, applied science is invaluable; while if the student is interested in art for art's sake, then the classics should dominate the situation; but the best

(Continued on page 34)

RANDOM THOUGHTS ON ENGINEERING EDUCATION

By PROF. A. G. CHRISTIE
Professor of Mechanical Engineering, Johns Hopkins University, School of Engineering, Baltimore, Maryland

ONE rather hesitates to write an article on Engineering Education. The subject has been discussed by so many leaders of the engineering profession that practically every phase has been fully covered. The following paragraphs will, therefore, present only some random thoughts on the question rather than a reiteration of points of view ably discussed elsewhere. One's views on questions connected with one's life work are naturally colored by local problems and local conditions. The writer may therefore offer points of view quite at variance with the methods and practices at your splendid Institute.

What seem to be outstanding demands for changes in methods and curricula of Engineering Education? The principal complaint against college graduates comes from leaders in industry who maintain that college men are too highly specialized along technical lines and lack that broad cultural training which seems necessary for those who would aspire to executive positions or to leadership in public affairs. The amount of English required in many engineering courses has been reduced to a minimum so that the average graduate is unable to express himself forcefully and gracefully in good English either orally or in written text. He generally has little knowledge of history, political economy, social conditions, or public events, and lacks that broadening influence that is supposed to be a part of a liberal education.

The attitude of industry in demanding broader training for engineers is rather inconsistent with their current practice. Employers compete with one another for students just finishing their four year undergraduate work and then criticize these men for their lack of more complete training. Would it not be better if the industries did something to encourage the better men to take graduate work in college and thus to secure the further training demanded? Such encouragement might take the form of higher pay for men holding advanced degrees. Some leaders of industry already appreciate the importance of encouraging graduate study but a still wider acceptance of this idea is badly needed.

Other critics of our colleges are demanding that emphasis be placed on the necessity that engineers should enter public service and take part in civic affairs. The latter implies that engineers should be trained for political leadership. Engineers do in many cases develop a considerable degree of skill as organizers but few have used this to further their own political ambitions. Furthermore, it is rather doubtful if the engineer is fundamentally a politician, nor does his professional training develop those characteristic traits associated with politicians. The engineer develops the habit of attacking all problems analytically and after determining the facts, applies a direct solution. The public as a whole do not want such methods applied to civic affairs or they would not tolerate our average city government nor the methods of framing our Federal tariff where policies are not based on facts but on compromises. Engineers are, therefore, not temperamentally suited to deal with these matters after the manner of the politician. Last year Dean Kimball of Cornell University told us of the Engineering type of mind and pointed out that the engineer must apply his methods to the social problems of civilization resulting from his mechanical developments. This is a very laudable ambition but its adoption means that there must first be a changed point of view on the part of the public and a modification of our ideas on politics and political organizations. It is very apparent that broad cultural training will be an asset of tremendous value to the engineers who undertake to carry on the higher developments of our modern state.

Since it was impossible to get anyone to undertake the writing of "A HISTORY OF THE DEAN'S OFFICE," the series article which was to have been published this month, it has been replaced by this article which although not strictly in line with the rest of the series, nevertheless is of such interest to all concerned with technical institutions, that we feel it to be fitting.

How can those cultural courses which are usually associated with the Arts or Philosophy Departments of our universities, be incorporated in the Engineering curriculum? Many colleges have attempted to do so but this can only be accomplished either by displacing specialized technical courses or by greatly overloading the student with work. At Johns Hopkins University the former plan was adopted so that the average four year graduate receives a very thorough and specially emphasized training in Engineering fundamentals together with certain courses of a cultural character but with less specialized instruction than in other engineering schools. This arrangement makes it possible for the student to advantageously choose which branch of engineering he will follow upon graduation and furthermore he does not labor at a serious disadvantage should he later decide to change to another branch. The student may secure additional specialized courses in a graduate year should he so desire. A plan for a combined Arts and Engineering course has been recently worked out covering six years and is now a part of the Johns Hopkins curriculum. During the first two years the student receives the regular academic training and need not decide to take the combined course until his third year. During his third and fourth years he is required to continue in his regular A.B. course but takes three engineering courses among his electives for which credit is allowed towards the A.B. degree. After taking his A.B. degree he enters the third year of the Engineering course and completes it in two more years. However, he will be given certain engineering courses in addition to those in the regular four year course in place of certain required academic courses that he has covered in his A.B. training. Some students may complete this combined course in five years by carrying a heavy schedule in the A.B. course.

This six year course will be optional at first and the regular four year course will be maintained for the time being. Much thought has been given to this plan and its development will be followed with interest. In the first place it should develop the more highly trained engineer with broad cultural viewpoint that is now in demand in industry. In the second place it allows the student to be in University two years at least before deciding whether to take up Engineering, and even after taking his A.B. degree in this combined course he need not continue in Engineering unless he should so desire. Finally, it tends to place the Engineering School on a full professional basis like the Medical School, where an A.B. degree is required for admission.

There is a tendency in many colleges to make the curriculum too highly specialized and to pile work upon the students in both class and laboratory so that they simply become machines

grinding out problems and laboratory reports but with little time to think about what they are studying or to fully digest the information acquired. This is a most unfortunate tendency and one that seems to be on the increase.

Oxford University occupies a premier position among the world's universities. What special training is imparted to Oxford students in a more effective manner than at other universities? Evidently the advantage does not lie in superior lecture courses for other universities have as brilliant professors. Wherein lies Oxford's power? The general opinion seems to be that this power comes from teaching the students to think for themselves. The traditions of Oxford have a tremendous influence in molding student life and directing it into this channel. The men are thrown into intimate association with one another and by tradition are encouraged to consider and discuss among themselves questions of literary, political, scientific and economic importance. The stimulation of such discussion leads the student to further study of the subjects of special interest to him and to the gradual development of his ability to think for himself and to form his own opinions on these questions. This development of the student's habits of thought seems to be Oxford's outstanding accomplishment.

Are the engineering courses of our American colleges presented with the definite object in view of making students think for themselves? Are our students taught to think deeply or merely to recite? It has been the subject of frequent comment that graduates of European technical schools have a better grasp of fundamentals than the average American graduate. This suggests thoroughness of self-preparation. Are our curricula so crowded with work that the student has no time for meditation? Is student thought in America too much concentrated on athletics and social affairs to develop Oxford's methods of thought, if opportunity were offered? These are very pertinent questions and ones that should be given thoughtful consideration.

The writer has recently been impressed with two facts, largely local in nature, but of considerable significance in considering engineering education. The first is, that about one-third of the entering students in engineering at Johns Hopkins University fail in their second year, and the second is, that employers who have come to us for men, only want the best men. The first phenomena is partly due to the increased standards of our School of Engineering and to an attempt to eliminate the poorer men early in the course. These facts have suggested many questions.

There seems to be no place in the industries for the poor man. What becomes of the man who fails in his course and is dropped from college? How does this failure affect his general attitude towards life? A leading manufacturer recently accused the engineering colleges of being "Bolshevik factories," by admitting men who are unable to complete the courses or who discover after graduation, that they should never have been engineers at all. Does a man who fails face the future with a belief that he is incapable of any serious accomplishment in life? Are his expectations and ambitions hopelessly blasted? Has enough thought been given to the unhappiness that may result from this man's misfortune in university work? How can such things be avoided? Why have these men failed? Does the trouble lie in our standards of admission? Can standards of admission be devised which would have kept such men from entering engineering courses? Have these men really been done any injustice by pointing out to them, after they have been a year or so at college, that they are not fitted to be engineers though they may have talents in other lines? Should our courses be planned so that men may readily transfer into other courses and may even be encouraged to do so when they discover their unfitness for engineering? The combined A.B. and Engineering courses, previously mentioned, are expected to provide such an opportunity by giving the student sufficient engineering work while securing his A.B. degree to indicate to him whether he has interest and talent in that line. What is to become of the poorer students? Should they have been allowed to continue in engineering until graduation? Have they been treated fairly by being allowed to take professional training along lines in which they can never make any marked success? How else might these men have been dealt with? Where is their proper place in life?

But one will say that men have a right to take engineering training if they so desire and can afford it, so long as they secure passing marks in the courses. Whether they become bankers, farmers, preachers, shoe merchants or commercial salesmen, after finding they have no talent for engineering, seems to be a matter of no significance to many people. Might it not be better to place engineering training on a professional basis and to permit only the best men to continue in the courses? These more talented men almost invariably stay in the profession; the less fitted ones gradually drift into other work. Instruction, with classes of only the best men, would not be held back by poor students. Hence more thoroughly prepared men could be graduated. Smaller classes would permit closer personal contact between instructor and student, now so frequently lacking, and this contact should result in greater inspiration to the students. This line of thought has led the writer to advocate placing the engineering courses on a professional basis, for this plan seems to meet the demands stated in the opening paragraphs more fully than any other that has been presented.

What about instructors and professors? Are they all that might be desired? Sometimes we must admit that they are not. Possibly one of their greatest faults is lack of practical experience and lack of contact with industry. This might be corrected by engaging only experienced men as

(Continued on page 36)

THE TECHNOLOGY SERIES

Last year THE TECH ENGINEERING NEWS published a series of articles on the buildings, laboratories and business administration of the New Technology. This series met with such widespread approval among our readers that we are continuing the idea this year. Our new series is of a slightly different character, dealing with the great personalities and the more human side of the Institute. As our space limits us to only a bare outline of the subject, it is hoped that the new series will serve as an inspiration to further reading along this line. The topics which the series covers are as follows:

THE FOUNDERS OF THE INSTITUTE ..... October
Prof. H. W. Tyler, '84, Head of the Department of Mathematics.

FRANCIS AMASA WALKER ..... November
J. P. Munroe, '82, Secretary of the Corporation, M. I. T.

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Prof. William Emerson, Head of the Department of Architecture.

RELATION OF INSTRUCTOR TO STUDENT AT TECHNOLOGY ..... March
Prof. L. M. Passano, Department of Mathematics.

GREAT GATHERINGS AT TECHNOLOGY..... May
I. W. Litchfield, '85.

COPPER IN MODERN STEELS

II. CORROSION

By GEORGE J. FERTIG
Graduate Student, Massachusetts Institute of Technology

BENJAMIN FRANKLIN was more of a philosopher than he was an engineer, but no one will dispute that his notions of economy and science correctly entitle him to the principal distinctions which characterize successful modern engineers. He may not have been familiar with

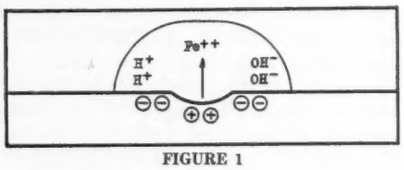


FIGURE 1

the intricacies of transportation, with the problems of power transmission or with the operation of the filter press, but his fundamentals of economy show that he held solutions to many questions which are of present day concern. If it be true that "a penny saved is a penny earned," how much more important is it to realize that a pound of steel in a finished structure saved is many times more valuable than a pound of steel as it passes under the finishing rolls of a mill! When a structure deteriorates, not only is there an economic loss in the disappearance of the material itself, but there is frequently greater loss in the time and effort of fabrication and replacement.

Economy and corrosion are inseparable for the principal factor in deterioration is corrosion. A number of interesting phenomena owe their existence to the presence of copper in the composition of steel. Corrosion is one that vitally concerns all industrial enterprises and in this paper only the effects of copper upon the corrosion of steels will be presented.

The earliest records of history contain accounts of the disintegration of

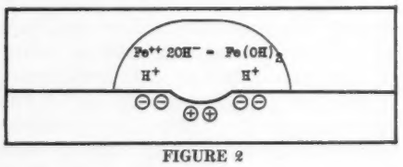


FIGURE 2

metals but this gradual destruction did not seem to attract serious attention. As the years progressed occasional individuals undertook to experiment with iron and its destructibility by external agents, in each case prompted by motives peculiar to his own tastes. Care was not always taken to control conditions of experiment, each seemed to obtain different results from his work and, therefore, the neophyte in the field of corrosion finds a literature full of apparently conflicting conclusions which must be brought into order and harmony. Recent years have witnessed the more careful study of all conditions attending the process of corrosion, however, and what seemed unconnected and diverse in the past has been brought into accord by well directed scientific experiment and thought.

Corrosion is a surface phenomenon which consists primarily and essentially in the solution of a metal through contact with an electrolyte. An electrolyte is a water solution containing positively and negatively charged particles called ions. When a piece of iron or steel is placed in acid of the proper

This article is specially prepared for THE TECH ENGINEERING NEWS from actual data obtained by Mr. Fertig. Part II, printed in this issue, deals with the corrosion features of copper steels. Part I, which was published in the March issue, dealt with the hardness properties of these steels.

strength the metal dissolves and hydrogen gas is evolved. When a like piece of iron or steel is left in a moist atmosphere it becomes covered with rust. In both cases the metal is dissolved. The electrolyte in the first case was the acid solution; in the second instance it was the water and oxygen of the atmosphere. Both examples were cases where the steel was corroded.

When a drop of water is allowed to fall or condense upon the clean metallic surface of a bar of iron there are several tendencies which will immediately assert themselves. Water is inclined to dissociate slightly, forming in so doing, equal numbers of positive hydrogen ions and negative hydroxyl ions. Into the portion of the undissociated droplet of water oxygen from the air dissolves slowly. At the junction of the water and the metal, iron tends to go into solution as ferrous ions at those points which are most electropositive relative to their adjacent areas. (Fig. 1.) As the atom goes into solution, it takes on positive charges leaving the area from which it left equally though oppositely charged. These ferrous ions combine with the hydroxyl ions originating from the water to form ferrous hydroxide while the corresponding hydrogen ions surrender their positive charges to the negative portions of the metal surface and combine to form hydrogen gas. (Figs. 2 and 3.) This gaseous hydrogen unites with the dissolved atmospheric oxygen to form neutral molecules of water. (Fig. 4.) Ferrous hydroxide is simultaneously converted into ferric hydroxide. (Fig. 5.) The same con-

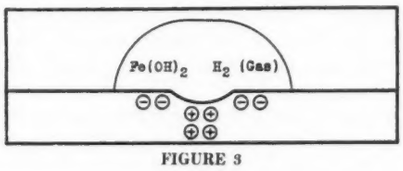


FIGURE 3

ditions which initiated this entire process are still influential and the cycle is repeated many times. When the water droplet disappears through combined chemical action and evaporation, the materials which were formed and held by it are deposited over the metal and left to mark the scene of corrosion. (Fig. 6.) Such is the electrolytic theory of corrosion which serves together with its very similar counterpart — the acid theory — to form the framework upon which corrosion in general is built. The acid theory differs from the electrolytic theory only in that it postulates the presence of other negative ions in the electrolyte in addition to the hydroxyl ions of the water.

Although this theoretical consideration appears to be simple in form, it is not possible to predict accurately through it the share which copper would definitely have in the corrosion of a copper-bearing steel for, in truth, corrosion is actually a very complicated function of a large number of variables. It is possible to see from the example just given that such factors as temperature, the purity of

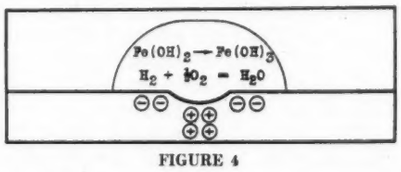


FIGURE 4

the iron and the oxygen content of the water would influence the rate of rust formation immensely. To these variables may be added the solution pressure of the iron, internal strain in the metal, its heat treatment, its mechanical treatment, the hydrogen ion concentration of the water, the hydrogen overvoltage of the metal and its included impurities, the con-

centration of ferrous and ferric ions in the water, the catalytic effect of various agents upon the reaction of hydrogen and oxygen, the presence of foreign material in the water, the tenacity and density of the rust coat formed, as well as the factor of film formations assumed by the liquids at

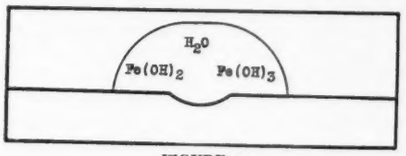


FIGURE 5

their air or metal surfaces. By altering the influence of any one of the variables, several or many of the remainder may be affected in diverse ways. Indeed, the various forms in which a metal may be wasted away are but occasions where prominence is given to one or more of the different variables enumerated. When the same piece of metal undergoes corrosive action the same variables do not always hold sway throughout the process but there are periods where different sets of them are in control. Very distinct factors are discernible when a steel corrodes in air. The presence of the products of disintegration in constantly changing amounts, the intermittent protection and exposure caused by the rust film and its crumbling and falling off, together with the collective effects of snow, rain and sunlight, present complications which vary widely even though action be practiced upon the same kind of steel. Rusting which proceeds out of excessive contact with air is likewise the summation of a multitude of primary effects many of which themselves have changing influences as corrosion progresses. (Fig. 7.) (Fig. 8.) (Fig. 9.) With all of this seeming complexity, however, experimental tests are very indicative of the controlling variables and point out with sometimes striking certainty the influence which certain factors have. Particularly is this the

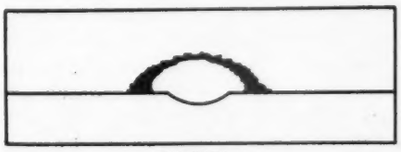


FIGURE 6

case in the determination of the effect of copper upon corrosion.

With such intricacy and interrelation as that with which an experimental determination of resistance to corrosion must deal it is evident that great care must be exercised in securing the relation between the copper content of steel and its rusting qualities. By subjecting a series of steels to tests in which the only variable factor would be the copper content such a relation has been found, first, in the case where the steels were exposed to an inland atmosphere, secondly, where exposure was made to open ocean air and, thirdly, where steels were allowed to corrode immersed in twenty-five per cent sulfuric acid. (Fig. 10.) In each of these tests the amounts of carbon manganese, phosphorus, sulfur and silicon naturally present in steels were held practically constant. Likewise the heat treatment and the mechanical treatment were carefully regulated to be the same for each steel. Control over each of the numerous conditions was exerted with the view always to limit the effect upon corrosion to that due to the presence of gradually increasing amounts of copper. From the results it is evident that copper improves the resistivity to corrosion in these particular cases.

From a study of the modern theories of corrosion it has been shown that

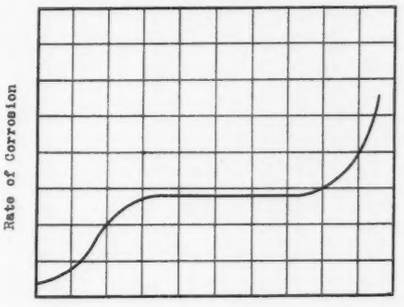


FIGURE 7
EFFECT OF H^+ ON THE RATE OF CORROSION

the effect of the presence of copper in a steel upon its rusting tendencies cannot be accurately predicted. Actual scientific tests upon copper bearing steels subjected to corroding agencies have been the only true criterion to follow in ascertaining the relative wasting properties of these steels. From such carefully regulated tests the relation of copper and corrosion has been demonstrated. But as yet only theoretical and scientific aspects of the subject have been presented. To stop short of a consideration of the behavior of copper bearing steels in industrial service would be to overlook the practical source where information concerning copper and rusting qualities might be obtained. It would be a difficult matter to attempt an analysis and determination of the simple factors which in a specific instance governed the rate of corrosion of a steel because it is not possible to differentiate the mechanism of the rusting process itself. The investigator must content himself with measuring corrosion as a complex integral of many variables and must interpret his overall measurement without being able to distinguish the various components which combine to give him his experimental result. But if sufficient care is exercised to control all of the chang-

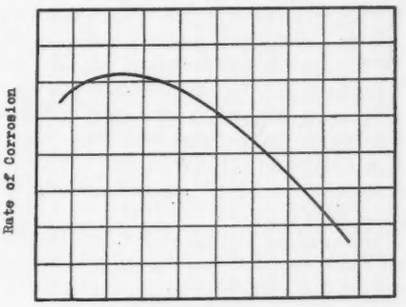


FIGURE 8
SALT CONTENT VERSUS CORROSION RATE

ing quantities save one it is plausible to believe that the effect of this one, however complicated, may be observed. In the instance of the behavior of copper bearing steels in service it is frequently evident that certain degrees of success of these steels may be attributed to their increased resistance to corrosion due to their copper content.

It would be an arduous undertaking to engage in an effort to correlate the various circumstances under which corrosion initiates itself and proceeds. The ordinary rail, sometimes half buried in roadbeds, undergoes the action of the atmosphere and abrasion on its head and attacks of different varieties on its web and base. Structural steel may be subjected to manifold conditions of protection or exposure depending upon whether it is deeply imbedded in concrete or bared to the air. Nails driven into wood suffer in accordance with the physical and chemical characteristics of their surroundings. The metal in pipe lines meets a different opposition inside from that which it encounters without. Steel immersed in water of various

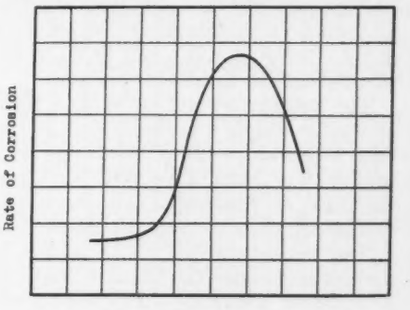


FIGURE 9
EFFECT OF OXYGEN ON CORROSION RATE

qualities reacts in as many different ways as there are media with which it comes in contact. In short, evaporators, chemical apparatus, gun tubes,

(Continued on page 30)

SUBMARINE SIGNALLING

By R. L. WILLIAMS, '01
Submarine Signal Company, Boston, Massachusetts

DURING the last two years we have all become familiar with the broadcasting of radio, but comparatively few know about the submarine signals which for nearly twenty-five years have been broadcast from lightships and submarine bell buoys all over the world to guide mariners in time of fog.

Submarine signals differ from those of radio in that they are actual sound waves traveling through water, whereas the radio signals are electrical waves traveling through the ether.

It has been found that water is an excellent medium for the transmission of sound, in that it is more uniform in density than air and that it propagates sound with a velocity approximately four times that of air.

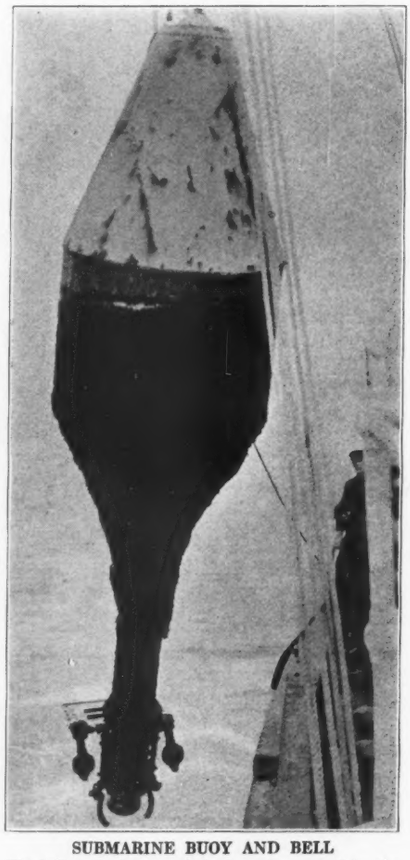
While this fact has been known for many years, Colladon and Sturm having measured the velocity of sound in water at Lake Geneva in 1836, it has only been in the last quarter of a century that practical use has been made of submarine signals. The submarine Signal Corporation of Boston was the pioneer in this art and since its start has maintained a corps of scientists, inventors, and engineers who have made a study of this new method of signaling until now it has reached a large field of usefulness, over three thousand five hundred vessels having been equipped with the submarine signal apparatus.

During the World War submarine signalling had a new use in the detection and locating of submarines and an immense amount of work was done on the subject not only by our own government but by foreign countries as well. During this period of intensive study great advances were made, particularly in the receiving devices and methods of obtaining the direction of submarine sounds, such as the noise of a submarine boat's propellors.

The submarine bell is the first form of sender which was developed and is still used, although a more powerful sender has been invented by Prof. Reginald A. Fessenden, known as the oscillator, which is now supplanting it.

The submarine bell is 15 inches in diameter, weighs 220 pounds, and has a pitch in water of 1,215 vibrations per second. It differs from the ordinary air bell in that its sound bow is much thicker and heavier. The bell for lightships is mounted on a case containing the mechanism for striking it, and is suspended overboard 25 feet below the surface of the water. The mechanism is operated by compressed air, a twin rubber hose leading from the bell to the air pipes on the deck of the vessel which connect with a small steam-driven air compressor and code valve.

The code valve regulates the supply of air to the bell so that it will strike the number of the lightship. For instance, Boston Lightship has the number 54, and the captain hearing this number will know he is approaching that lightship.



SUBMARINE BUOY AND BELL
The bell at the bottom of the buoy is operated by the action of the waves

Most of the lightships on the coast of the United States and Canada, and many lightships of foreign countries are now equipped with submarine bells. The distance they can be heard depends upon a number of things, such as whether the sound is ahead, on the beam, or astern, the condition of the sea, and the speed of the ship. The submarine bell has been heard as far as 25 miles. The average distance is from 5 to 10 miles.

Besides being hung from lightships, submarine bells are attached to the bottom of buoys which are anchored at dangerous points on the coast. The submarine bell buoys are operated by the action of the waves and hence do not ring a regular code. Their rate of ringing depends on the roughness of the sea and varies from 4 blows a minute for a comparatively calm sea to 40 blows a minute for a choppy one.

The submarine bell is mounted on the bottom of a mechanism case which is bolted to a large tube extending from the bottom of the buoy. Passing through the mechanism case is a horizontal shaft on which is a vane. The motion of the buoy up and down in the water tips the vane and turns the shaft which is geared to mechanism compressing a large spring which when compressed is automatically released and during its stroke pulls over the clapper, striking the bell. The mechanism case is water tight and filled with oil which lubricates the moving parts.

When one considers the fact that the submarine bell buoy is ringing continuously day in and day out for a year at a time without any attention whatever, its performance is truly remarkable. A counter placed in one of these buoys has registered as many as 8,000,000 blows in the course of a year.

Whenever there is a fog, the submarine bells on lightships are rung, and vessels equipped with submarine receiving apparatus not only can identify the lightship by counting the code of the bell but can determine its direction as described later. The fact that the bells on the buoys are ringing in fair weather as well as foul weather enables the captain at any time to listen to them and check up the condition of his receiving apparatus.

While the submarine bell proved to be very useful, there arose the problem of designing a sender for navies which would send Morse signals. This was for communicating between submerged submarines and surface vessels and also between battleships to augment the radio or for use should the antennae be shot away. The submarine bell was not suited for this work, as its maximum rate of striking is too slow. This led Professor Fessenden to invent the oscillator, which not only permits telegraphing but also gives a louder signal than the bell.

The oscillator has a large steel diaphragm two feet in diameter which is vibrated electrically. The face of the diaphragm being in contact with the water transmits its vibrations to it. On account of the tremendous pressure set up by the vibrations of the diaphragm a powerful sound is produced which has been heard as far as 60 miles.

The oscillator diaphragm at its outer edge is bolted to a water-tight steel

case containing a large coil of wire which is called the field coil. Through this coil direct current is passed. Inside the field coil with its axis coinciding with that of the field coil is another coil known as the armature coil through which is passed alternating current of 540 cycles per second.

Between the field and armature coils is a copper tube with its axis also concentric with that of the coils. This copper tube is supported by steel discs at each end which are mounted on a steel shaft screwed into a boss on the centre of the diaphragm.

The alternating current in the armature winding induces a current in the copper tube. The current in the copper tube reacts on the flux of the field coil causing the tube to oscillate in the direction of its axis. The motion of the copper tube is transmitted by the discs and shaft to the diaphragm.

The discs and diaphragm are very carefully tuned so that their combined resonant frequency will be 540 cycles per second.

Alternating current for operating the oscillator is obtained from a motor generator of the type used for radio. A two kilowatt set will operate a single oscillator, but as generally a vessel has two oscillators, a five kilowatt set is installed so that both oscillators may be sounded simultaneously.

Oscillators are mounted in the bow of a vessel, one on each side, by cutting a hole in the ship's plate, riveting in a reinforcing ring to stiffen the edge of the hole, and bolting the flange of the oscillator diaphragm to the ring so that the face of the diaphragm will be flush with the outside of the ship.

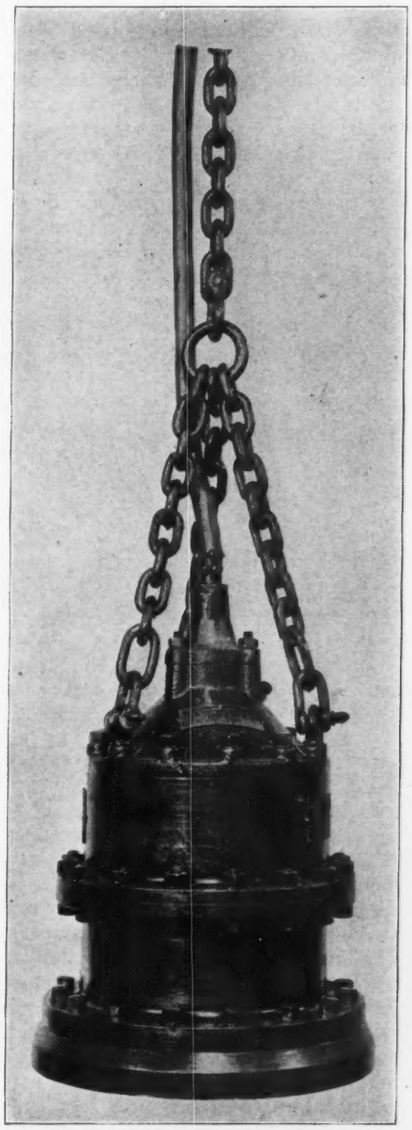
Another method of mounting the oscillator is in a tube passing through a "sea chest" in the bottom of the ship. With this method the oscillator diaphragm faces downwards and is lowered about two feet below the bottom of the ship. Sound is then sent out in all directions equally well.

The oscillator described above has been used extensively on submarines and battleships. Within the last year a new oscillator has been made, designed for hanging overboard from a lightship in place of the submarine bell. This oscillator has a resonant frequency of 1,050 cycles, and it is smaller, weighing about 500 pounds. whereas the first oscillator weighed 1,200 pounds and was too heavy to conveniently raise and lower by a hand windlass on a davit.

For sending telegraph signals a key in the oscillator armature circuit permits sending dots and dashes which sound similar to those of radio. When the oscillator is used as a fog signal on a lightship, a code machine directly connected to the motor generator sends out any desired code.

The oscillator can also be used as a receiver of sound. All that is necessary is to throw a switch connecting the armature wires of the oscillator to a telephone receiver instead of to the motor-generator.

The sound coming through the water vibrates the oscillator diaphragm,



THE LIGHTSHIP OSCILLATOR

The oscillator has a resonance frequency of 1,050 cycles, and can be used to receive as well as to transmit messages.

which in turn, by means of the shaft and discs, vibrates the copper tube. The motion of the copper tube induces current in the oscillator armature winding which flowing through the telephone reproduces the sound that was in the water.

Vessels equipped with oscillators for sending signals therefore require no additional apparatus for receiving submarine signals. Vessels without oscillators are equipped with microphones which will receive both bell and oscillator signals.

The submarine signal microphone is similar to the ordinary telephone carbon button transmitter, except that the diaphragm is mounted on a water-tight case so that the microphone may be submerged. The carbon button is also of the "inertia" type instead of the "solid back" type. The thickness and diameter of the microphone diaphragm and the parts of the carbon button are designed to have approximately the pitch of the submarine bell.

The microphones are suspended in two tanks located near the bow of the ship, one on the port side and one on the starboard. The tanks are about 16 inches square by 18 inches deep, are filled with water and bolted tight against the inside of the ship's plate.

The bell or oscillator sound passes through the side of the ship into the water in the microphone tank and is there picked up by the microphone.

From the microphone, wires lead to the pilot house to a direction indicator box. This box contains switches whereby the listener can connect either a port or starboard microphone to a telephone receiver.

When the bell sound is equally loud on both port and starboard microphones, the bell is dead ahead. When the sound is louder on the port microphone the bell is on that side of the ship, and similarly on the starboard when louder on that side. To determine the direction of a bell the ship is then swung to port or starboard until the sound is equal, when the captain knows that he is heading directly for the bell.

The reason that the sound is louder on the side of the ship that the bell is on is that the microphone on the opposite side from the bell is screened by the hull of the ship.

During the World War a new system of determining the direction of submarine sounds was invented, known as the "binaural" method. Curiously enough it was independently invented and used in Germany as well as in this country, although it reached a higher development here.

The "binaural system" is the same method which one uses for determining the direction of sound in air applied to water. A person standing in the open country, with eyes closed, can point towards the source of a sound and can determine the exact direction by turning the head so that the sound appears to be in the direction he is facing. The effect is due to the time of arrival of the sound at each ear being slightly different, unless he is facing the sound, in which case the arrival at each ear is simultaneous. It is astonishing what small differences in time will produce a change in the sense of direction. As

(Continued on page 36)

MUTUAL INTERESTS OF FORESTERS AND ENGINEERS

By JOSEPH KITTREDGE, JR.
United States Department of Agriculture, Lake States Forest Experiment Station, St. Paul, Minnesota

FORESTRY is an applied science, and in that respect, it closely resembles engineering. In addition to a field of its own dealing with the characteristics of the forest trees and forests as biological units and their modification or control to make them most productive and most useful, it involves the application of many sciences to the preservation and protection of forests for essential human needs. Biology, chemistry, physics, climatology, geology, all contribute to the practice of forestry. Certain phases of economics and sociology are directly applicable in the development of forestry. Engineering, itself, forms the basis for several essential forest activities.

There are many points of contact and mutual interest between the forester and the engineer, which are not completely recognized. The obvious applications of engineering in forestry include the surveying and mapping in connection with boundary locations, topographic maps, timber surveys and the construction of roads and trails and other improvements which are as essential in the proper handling of forest property as they are in the development of any other land property. The construction of roads and trails and bridges demands engineering training and experience. The installation of telephone lines in mountainous, inaccessible, heavily timbered country requires a certain kind of engineering skill. Types of lookout towers have had to be devised, with the help of engineers, which would combine the strength necessary to withstand exposure to the severest storms, with the lightness which would permit them to be transported on horseback, or even by man power, to precipitous mountain peaks.

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A BIT OF THE OLD NORTH WOODS WHICH LUMBERING AND FIRE HAVE NOT REACHED

© *American Forestry*

DESTRUCTION BY FIRE IN THE TONGASS NATIONAL FOREST, ALASKA

Occasionally, portions of the forest become excessively dry, and over extensive regions are highly inflammable, requiring very effective patrol to prevent such serious damage as shown above

In logging engineering, as an aid to forest operations, the engineer has been called upon to develop machinery and railroading methods which would be applied to the handling of big logs and heavy loads in the roughest country. The high power and high speed donkey and overhead skidding methods, which have been developed on the Pacific Coast, are good examples of engineering ingenuity. At the same time, these high power devices when they are used with cables to collect the logs from the points where the trees are felled to rollways along the railroads, are often a serious menace to the future forest. Over large areas the ground is completely stripped and the young forest growth which often has started under the timber, is almost wholly destroyed. In this respect the greater destructivemess of engineering devices as compared with horse logging has been a drawback rather than a help to forestry.

The application of economic principles, so important in engineering production, is also a necessary part of the intelligent handling of forest crop-producing land. Forest economics is fundamental in the matter of national timber supply and the development of a national policy of forestry. Only west of the Great Plains is the remaining supply of old growth timber sufficient to supply the demand of a large part of the country for more than a few years. As more and more of the timber has to come from the West, the supply of freight cars for its transportation becomes a serious problem in itself, second only to the increased prices to the eastern consumer, who must pay cost of production plus freight charges. The timber production in the country, as a whole by growth, is only about one-sixth of the present consumption. Obviously such a relation cannot long continue in combination with the diminishing supply of old growth, without the development of a serious shortage. And as the supply of timber dwindles in relation to the demand, a reaction in the form of increasing prices is inevitable. Hardly second in importance to this relation of supply and demand to prices, is another phase of economics, namely, the place of forests as a form of land utilization. The value of land for the production of agricultural crops has long been realized, but until recently, the forest has been considered only as a hindrance to clearing or as a mine to be exploited. Now it is being recognized, that on the poorer, rough, stony or sandy lands where no other crop will succeed, forests may be grown profitably.

In the northern states which have short growing seasons frequently combined with considerable areas of com-

paratively poor land, the farmers often find it difficult to make a satisfactory living from their farms alone. It is undoubtedly this situation which has been responsible for the abandonment during the past fifty years of many farms in New England and New York A piece of woodland in connection with each farm, or a wood-using industry, in either case managed and operated as a permanent resource so that there would be woods operations annually, would give the farmers a chance to utilize their time and that of a team during the slack winter period to help out the farm income. Such a permanent community would justify a corresponding development of stores and commercial enterprises which would also be on a permanent basis. In sharp contrast with such possible communities in forested regions are the examples of transitory sawmills and wood-working plants which have used up the available supplies of raw material and either closed down or moved elsewhere, leaving what had been a flourishing community to dwindle and gradually disintegrate. This possibility of permanent, prosperous, forest communities is the best example of the relation between sociology and forestry.

The applications of physics and chemistry to forestry as best exemplified by the Forest Products Laboratory of the United States Forest Service are undoubtedly familiar to most engineers. The standardization of lumber and timber grades, the development of new uses for wood of different species, the better utilization of wood for specific purposes, the improvement of chemical processes, such as are basic in the pulp and destructive distillation industries and methods of preservation of poles, posts and railway ties are common examples. It has been suggested that the chemistry of cellulose may ultimately lead to a form of wood utilization much more efficient than the present one by which all wood will be pulped and the cellulose remolded or remanufactured in forms and in different qualities which will be best adapted to the uses to which they may be put. For the forester this possibility suggests a happy solution of the use of small sizes and inferior species which are now unmerchantable and often act as forest weeds in choking out the growth of better species. It is well known that the physical properties of wood vary within the same species of wood. Timber from certain regions or from certain trees is better suited by its strength or its density or its toughness than that of the same species from other trees or regions. What are the reasons for these variations? Presumably they will be found in the conditions under which the trees grew. They may be related to the rate of growth or to the density of the forest or to the combination of climatic factors or to the physical and chemical qualities of the soil. If they can be worked out it offers the opportunity

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HOW PORCUPINES KILL TREES

They eat the bark, girdling the tree near the ground, or climbing the tree, strip the more tender bark from the top.

for the forester to regulate the growth of the forests by cultural methods, so that the most useful and valuable products may be secured. The application of chemistry and physics to the properties and uses of wood has already resulted in improved methods of utilization, decreased costs and better adaptation of products to human needs. The relation of this work to forestry is not so obvious. It is becoming increasingly important, however, as a means of conserving the forests and timber supply by better utilization of the cut products for future use.

Geology and soil science contribute directly to an understanding of the sources, amounts, kinds and availability of the water and food which are essential for the growth of trees, and which are responsible in part for the observed distribution of our forests and their varying rates of growth. The reclamation of sand dunes, of eroding mountain slopes and of river banks are special problems related to geology, forestry and engineering. Frequently the reclamation can best be accomplished by the planting of suitable forest trees to bind the soil. Enormous quantities of willow fascines, a forest product, are used annually in the revetment work along the Mississippi River.

An understanding of climatology is essential to the forester. Temperature precipitation, atmospheric moisture, wind and evaporation in conjunction with light and soil conditions control the distribution and rate of growth of the forests. Those species which are best adapted to a particular combination of these factors are the ones which survive in any given region. Wind is also an important agent in the distribution of seed by which many kinds of trees provide for the establishment of a new generation under favorable conditions. One of the most important problems in forestry in the United States today is the prevention and control of forest fires. The relative fire hazard is directly dependent upon the inflammability of the forests and the surface layers of leaves, twigs and duff. It is the moisture content of these materials which determines how readily they may be ignited and which underlies the rate of spread of a forest fire after it starts. The moisture content in turn is dependent upon the climatic factors of precipitation, rela-

(*Continued on page 28*)

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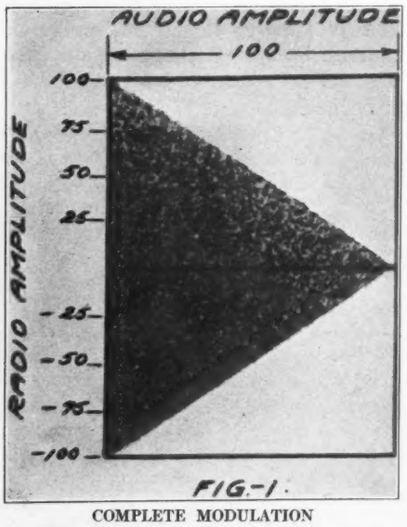
THE FOREST PRIMEVAL—RICH HERITAGE OF A CONTINENT

THE CATHODE RAY OSCILLOGRAPH

By PAUL B. FINDLEY
Technical Publicity Section, Western Electric Company

THE principle of the cathode ray oscillograph was discovered by Braun twenty-five years ago and the tube has always been known by his name. In Braun's tube, however, the electrons were produced by a high voltage discharge, between the metal terminals through the remnants of gas left in the tube. Some of the electrons went through a tiny hole in the terminal plate and struck the end of the tube making a spot of light where the stream of light ended. If an electric voltage was applied between the plates the stream would be deflected toward the positive plate and the spot moved across the screen.

The Braun tube had two major limitations. The air left in it became gradually exhausted and had to be renewed, while the voltage required to operate it was from ten thousand to fifty thousand volts direct current. The apparatus necessary to generate a current of this voltage and its maintenance was expensive and it was also dangerous for the operator to handle. In addition the tube was not stable. The electrical characteristics varied with the amount of gas in the tube and the electron stream was falsely deflected by negative charges collected on the glass walls of the tube. These charges collect on the walls of the tube because the pressure of the gas is not high enough to dispose of them. For these reasons the Braun tube was never used as much as it deserved



COMPLETE MODULATION
The radio amplitude varies from 100 to zero

when its advantages were considered.

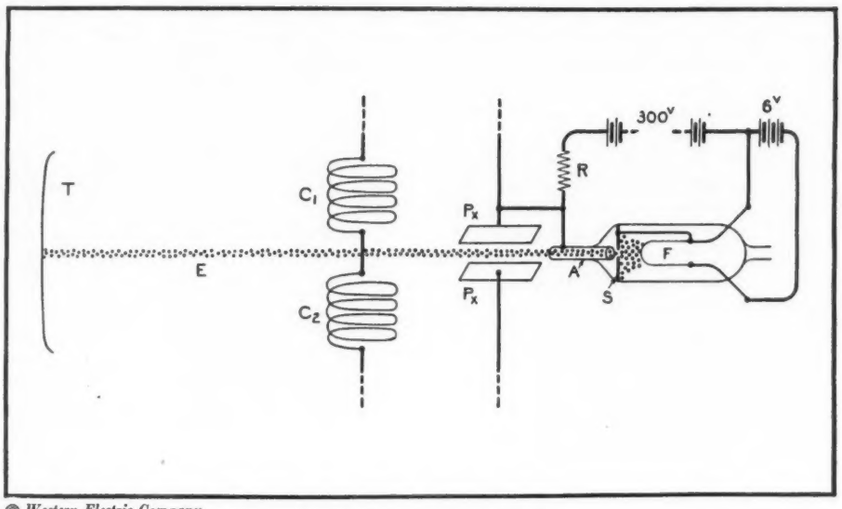
The development of the vacuum tube, however, opened up a way to obtain the stream of electrons more easily by the use of the heated filament. In the drawing F is the filament which is heated by a six volt battery as in the ordinary vacuum tube. Another battery built up of small radio "B" cells provides three hundred volts between the filament and the other electrode "A." This electrode is in the shape of a little tube. The voltage at which it is maintained draws off the little electrons from the filament. They pass through the hole in the plate "S" and down through this tube. From there they shoot on down between the plates P_x to the end of the vacuum tube where they strike the chemical coating of the screen, making a bright dot. To simplify matters only one pair of plates is shown in the diagram. The other pair is at right angles to the first and is used to swerve the beam at right angles to the motion produced by the first pair of plates. One plate of the pair Px has a lead which passes through the glass to a terminal and the other is connected to the tubular terminal "A" and from there to a terminal outside the tube. In this way when a voltage is put across the two plates the stream of negative electrons will be swerved toward the positive plate.

When it is desired to measure a current instead of a voltage, two small coils of a few turns of wire are placed on opposite sides of the tube. The magnetic effect of the current deflects the electron stream in a direction parallel to the plane of the coils and the luminous spot will be moved as before.

In the cathode ray oscillograph as developed by Dr. J. B. Johnson, the disadvantages of the Braun tube have been overcome. The adoption of the heated filament did away with the necessity of maintaining a high voltage between the filament and the other electrode. The elements were so designed that the electrical characteristics of the tube were maintained independent of the pressure of the gas in the tube. It was found in the development of this tube that when it was exhausted to a very high vacuum the individual electrons of the stream separated. This stream of electrons shooting out through the tubular electrode resembles very much a stream of water from a hose with which a small boy can draw designs on a board fence. The electrons separate, just as the globules of water do, making the stream wide where it strikes the end of the tube.

Of course the boy when making his figures on the fence doesn't care whether the pencil he is drawing with is an inch in diameter or a foot. However, when you are going to calculate the action of an electric current you must use a sharp pointed pencil. So a way had to be found to focus a stream of electrons down to a very fine point.

Consequently, engineers made up a tube containing a small amount of argon, an inert gas. First they exhausted the tube of all the air possible, even to baking the glass while it was being exhausted, so as to release from the glass all the gas which could be freed by the heat generated during operation. Then the argon gas was introduced.



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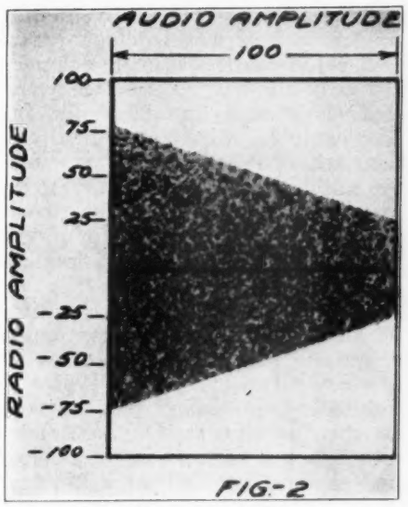
HOW THE TUBE WORKS

F is the filament; *S* is a shield, with small opening; *A* is the tube anode; *R* is a protective resistance; P_x are plates connected to potentials to be measured; C_1 and C_2 are coils (outside of tube) to measure current effects; *E* is electron stream; *T* is the target

Now argon is made up of monatomic molecules, each of which has a nucleus positively charged with electricity, and surrounded by two negatively charged electrons held to it by electric attraction. In the operation of the tube the free electrons shoot down the tube at a velocity of six thousand miles



INCOMPLETE MODULATION
The radio amplitude varies from 75 to 25

per second and when one of them hits one of these molecules which is moving at the rate of only one-quarter of a mile per second the force of the collision knocks off one or more electrons from the molecule. Formerly the positive charge of the nucleus was neutralized by its ring of negative electrons but when some of the electrons are knocked off, the nucleus, now positive, begins to attract free negative electrons. As these nuclei are heavy as compared to the flying electrons they are simply buffeted around by the latter and they stay in the line of the electron stream where they are formed. Therefore, there is along the whole length of the electron stream a line of positive nuclei which attract the free electrons and hold them in the straight and narrow path in spite of the repulsion between electrons which tempts them to spread out. Further, the dislodged electrons shooting off in all directions soon fill the space outside the stream with negative charges which repel the flying electrons, keeping them in their own path. In addition the pressure of the gas in the tube is high enough to denude the glass walls of the tube of negative electric charges.

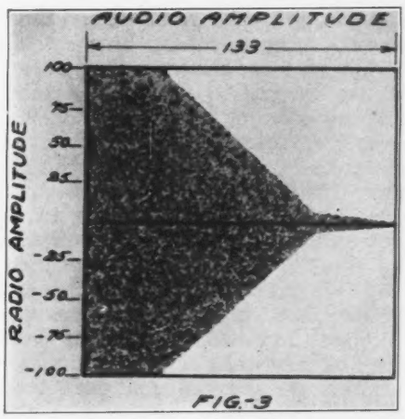
In order to prevent the bombardment of the filament by positive ions which destroy its oxide coating and thus render it inactive, the filament is sealed in the glass mounting tube, and to prevent the ions from striking the filament when they come through the hole in the plate "S" the filament is bent in a circle as shown in the photograph. The filament is made of ribbon instead of wire which leaves just an edge exposed to these ions.

The great advantage of the cathode ray oscillograph lies in the fact that the stream of electrons forms a nearly weightless pointer whose movement will accurately follow the changing conditions in the circuit to which it is connected. By avoiding mechanical inertia, as it does, it is capable of recording frequencies up to millions of cycles per second.

This interesting instrument can be used in many ways. When one set of deflector plates alone is used the electrical potential to be measured causes the luminous spot to become a bright line whose length is proportional to the amplitude of the voltage wave. If now another voltage varying with time is applied to the other pair of plates the beam will be swept across the field and its wave-form can be seen. Thus, by speaking into a telephone transmitter one can "see himself talk."

The familiar "hysteresis loop" can be shown most vividly with this oscillograph. The magnetizing current moves the spot "from side to side" and the resultant magnetism in the sample moves it "up and down." In the Western Electric laboratories of the Bell System, such a set-up has been made by winding the magnetizing coil on a fiber tube, into which is slipped a thin strip of the material. The tube is so placed that the end of the sample comes up to the oscillographic tube where its magnetism can swerve the flying electrons.

By connecting each set of deflecting elements to alternating currents of different frequencies, the spot will trace out Lissajous figures. If the frequencies are steady and one is an exact multiple of the other the pattern will be stationary, otherwise it will change as the phase relation of the current changes. In Fig. 4 is shown a comparison of one hundred and four hundred cycles, but the ratio between the two may be much greater. For two currents differing widely in frequency, the pattern may be too long for its ends to appear on the coated end of the tube but the fact that it is steady shows that one frequency is an exact multiple of another. Thus the carrier wave of a broadcasting station may be amplified and impressed on one set of deflector plates, while a



OVER MODULATION
At left, radio does not respond to audio; at right, radio oscillations cease before end of audio swing is reached.

locally generated frequency impressed on the other set of plates is adjusted to a match with it. The local wave is then matched with another local frequency at say, one-hundredth its frequency and this in turn is "stepped down" to a frequency which can be measured easily.

In radio broadcasting it is important that the voice frequency voltage which modulates the radio frequency output shall be large enough to fully load the transmitter, yet not large enough to overload it. Direct evidence of this is given by connecting the cathode ray oscillograph in such a way that while the radio output moves the spot up and down the audio input moves it sideways. According to the theory of modulation, the radio current should

(Continued on page 28)

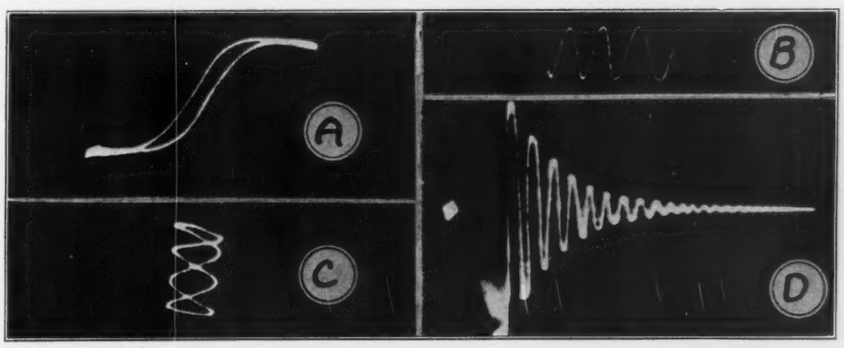


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FIGURE 4
WHAT AN OBSERVER SEES ON THE SENSITIZED END OF THE TUBE
(a) Hysteresis curve of hard iron wire. Made at 60 cycles; (b) 60 cycles alternating voltage; (c) Frequency match, 100 cycles and 400 cycles; (d) Damped oscillating discharge of a condenser through an inductance. $C=1$ Mfd. $L=3$ Henrys

ARTISTRY AND DEVOTION IN SALESMANSHIP*

By T. H. BAILEY WHIPPLE
Salesmanship Department, Westinghouse Electric & Manufacturing Company

WHY do so many salesmen fail to achieve high success in their chosen vocation?

In considering this subject, let us eliminate those possessing a low or even an average native capacity, and those of very meager culture, because concerning such the answer to the question is too obvious to justify discussion. Let us consider only those of real capacity; those of more than the usual culture and education; those who are more than ordinarily in earnest, and who have proved themselves to be not slothful in acquiring knowledge by the "filling-in" or usual process, and whose perceptive faculties are active; those who really have a very thorough knowledge of the products they offer for sale, and much auxiliary commercial, general, and even technical information. Let us also consider salesmen of character much above the average, and who industriously cover their terrirories and daily send in reports of the day's doings. Let us even go further and consider only those who have carried their mental industry to the point of rather thorough analysis of their product, their territories, and many other commercial features embodied in the equipment of an aspiring salesman.

Also let us consider those who are self-possessed and more than usually fluent in talking their goods. To make the case stronger, let us include in this equipment salesmen of pleasing personality, who are real friend makers; let us repeat our question, why do so many salesmen of such qualities and qualifications fall short of the "top-notch" class?

Many answers might be given, all true, so far as contributory truth is concerned, such as:

The pitch of enthusiasm being just a little too low.

Tactfulness not quite sufficient.

Aggressiveness not quite strong enough.

Judgment a little short of the necessary balance.

Intuitive recognition of psychological moment not strong to the point of positive assurance.

Courage or tact or both not sufficiently active when the psychological moment is discerned.

Abstraction or too great intensity of earnestness blinding one to quick discernment of the psychological moment.

Balance between dignified independence and persuasive persistence not effectively adjusted.

The relation between familiarity of friendship and valid business motive not definitely differentiated.

Taking a little too much or not quite enough for granted.

Over-credulity in relying upon promises of future action.

Over-confidence that fails in applying methods of sustained dynamic action.

Too much time spent with favorite customers to permit of creating the most new ones.

Poor judgment in adjusting efforts effectively between the entire line and selected products to be specially featured.

Many other minor shortcomings, the multiplicity of which is cumulative in negative effect, although individually hardly pronounced enough to be vividly recognizable in the field of the salesman's own consciousness, but while carrying him to the threshold of high success, fail to carry him across it.

Again our question, what is the cause or principle underlying this failure to carry this success of more than the usual standard to the point of very unusual achievement? If we will omit the consideration of superlative success, the result of genius itself, we may justly conclude that the failure under consideration is not the result of intellectual limitation, nor of inadequate ambition so far as the development of the thinking power is concerned, but rather because of an emotional inappreciation which fails to awaken the real devotional attitude from which all highly artistic performance emanates. This element of devotion to one's life work is an instinct, an impelling force, an æsthetic taste, susceptible to training and concomitant to all high expression of art, for art itself is the offspring of devotional intensity.

When we have this spirit of devotion, this pride of performance, even though our talent is not of the superlative kind, we will fight obstacles, glory in sacrifice, if necessary, and will realize with Michael Angelo that "Trifles make perfection, and perfection is no trifle." We cannot implant within ourselves the embryo of genius, but if possessing a fair measure of talent, we can arouse and develop this talent by patient and unremitting industry. We have a "thinker," and we should teach ourselves to think, just as we teach our hands to skillfully employ tools if work of high handicraft is to be accomplished. Salesmen not only do not regard themselves seriously enough, but they also fail adequately to estimate the dignity of their art. The same neglect practiced by salesmen in treating the many features of artistic expression, would wholly disqualify an actor for service in any reputable company of dramatic players.

How many salesmen "suit the action to the word"? How many ignore enunciation, inflection, and intonation of voice? How many strike keys with mechanical precision, but overlook the interpretative touch? How many, although not careless in phraseology and diction, yet fail to cultivate a style of expression harmonizing with the best in their own personality? How many, having even the rare accomplishment of excellent and distinctive style, yet fall short of forceful action! How many, possessing skill in diction, phraseology, style and action, yet are not strong enough in poise and reserve power!

How many, proceeding under the actuating impulses of necessity, duty, and even pride of performance itself, yet lack in real devotion to their work!

Devotion, like prayer, is rewarded more in subjective influence than by direct objective result. This dominating influence is susceptible of cultivation. Good taste, progressively cultivated, will gravitate toward it under the action of self-imposed tasks, sustained by the will and molded by habit. Says William Hanna Thompson, M.D., in speaking of the brain: "Another important conclusion is led up to by these facts, namely, that we can make our own brains, so far as special mental functions or aptitude are concerned, if only we have wills strong enough to take the trouble." I advise all my readers, especially young men, to read, study and practice the "Education of the Will," as outlined by Jules Payot (Funk & Wagnalls, Publishers). Most salesmen fail after qualifying in all other respects, because they inadequately consider the synthesis feature in their sales talks. This feature embraces the following:

Summing up of salient points.

Drawing conclusions.

Assisting the prospect to decide through powerful suggestion.

(*Continued on page 34*)

*NOTE: The third of a series of four articles contributed by Westinghouse E. & M. Company, in the hope that the information presented may be helpful to engineering graduates in analyzing themselves in relation to the engineering profession.

THE AUTOMOTIVE FUEL PROBLEM

By TYLER FUWA
Research Associate, Massachusetts Institute of Technology

A RECENT estimate indicates that by 1930 there will be registered in Massachusetts more than 900,000 passenger automobiles, a growth of 100 per cent over probable 1924 figures. Assuming this rate of growth to be a fair index for the country at large, a total of some 30,000,000 cars will be in operation only six years hence.

Will gasoline production keep pace with this enormous future demand? If not, what is to be done in the way of relief? These are questions deserving of much thought even today, when plentiful stocks of oil are on hand. First of all, let us review some petroleum statistics in order that a satisfactory background for discussion may be established.

Since the beginning of the oil industry shortly after the Civil War, more than 10,000,000,000 barrels of crude oil have been produced in this country alone. Our current production is at the rate of 550,000,000 barrels annually and amounts to 65 per cent of the world's total, as is shown by the following tabulation:

WORLD'S PRODUCTION OF CRUDE PETROLEUM FOR 1922
(*Millions of 42-Gallon Barrels*)

United States	551	65%
Mexico	185	22%
Russia	30	4%
Near Eastern Countries	76	9%
Total	842	100%

Our petroleum resources, however, amount to only 12½ per cent of the total for the world. This is all out of proportion to our production and means that within a decade we must begin to draw upon foreign fields for a substantial part of our "crude."

The importation of oil from these sources, already a fact, bids fair to result in some interesting political and economic problems. For years Great Britain has realized the tremendous industrial and military importance of petroleum, and in consequence has gradually strengthened her grip on oil-bearing lands until today she controls at least 70 per cent of the world's tangible resources. American capital, on the other hand, always profitably employed at home, has not found its way to oil fields across the water. The result is that we possess a highly developed domestic petroleum industry which produces nearly two-thirds of the world's output and at the same time controls but one-fifth of the world's resources. Competent geologists seem to agree that not more than 20 years' supply of petroleum is available from the seven important producing regions of the country. These estimates are based on the present rate of consumption and do not take into account our reserves of shale oil.

The solution of the problem of motor fuel shortage will undoubtedly be a composite one, somewhat as follows:

1. The partial substitution of other fuels for gasoline.
2. The partial substitution of other types of automotion, utilizing to a greater extent the electric motor, steam engine and Diesel type engine.
3. The exploitation of domestic oil shale as a source of petroleum supply.
4. The more efficient utilization of fuels, as a result of improved engine design and performance.

While there is no other liquid fuel quite as satisfactory as gasoline from a technical point of view, we could, if necessary, burn benzol and ethyl alcohol, both of which can be made available in considerable quantities and at a reasonable selling price. Benzol is a distillation product of bituminous coal, the yield being about two gallons per ton of coal. The futility of entirely substituting benzol for gasoline is apparent when it is realized that the distillation of our total annual production of 500,000,000 tons of coal would satisfy but one-sixth of the present consumption of motor fuel. Ethyl alcohol, on the other hand, can be produced in practically unlimited quantities from such cheap raw materials as sugar mill and paper mill wastes and even from sawdust. Alcohol is quite inferior to both gasoline and benzol in point of heating value and will not burn to good advantage in engines of present-day construction. Despite these limitations, it is well to bear in mind that the development of gasoline substitutes is a project worthy of serious consideration.

What of substitute engines? The preëminence of the gasoline engine is due very greatly to its high power and flexibility combined with light weight. For example, airplane engines weigh but two pounds per horse power and automobile engines average from eight to nine pounds per horse power. In contrast to this, the best steam power plants weight from 24 to 28 pounds per horse power, while an electrically driven car of any reasonable touring range has a still heavier power plant, due to the necessity of using storage batteries of high capacity. At present it appears unlikely that either of these latter types of automotion will displace the gasoline car, even to the extent of 10 per cent. It is certain, however, that steam and electric vehicles will be developed further for some commercial uses, where comparatively slow speed, short operating radius and excessive weight are not limitations of primary importance. Such a trend in practice will operate to conserve a very considerable part of our gasoline.

The Diesel type engine, which has been an unqualified success in marine and stationary power plant work, is practically the only other possible substitute for the gasoline engine. The outstanding advantage of the Diesel engine is its ability to operate efficiently on the cheaper heavy fuel oils. The production of a sufficiently light-weight engine of this type presents many difficult problems in design however and at best it will take many years of untiring research to adapt the Diesel engine to the peculiar requirements of automotive practice.

The oil resources discussed previously embraced only oil-bearing sands and pools from which the oil drains and is then won by pumping. Aside from this supply, however, enormous quantities of petroleum lie bound up in oil shale, the most important deposits of which are located in Colorado and Indiana. This reserve supply, although sufficient to fill our needs for upwards of a century, cannot be tapped by the comparatively direct method of drilling and pumping. The oil shale, containing, on the average, twenty gallons of petroleum per ton, must first be mined after the manner of coal, then crushed and finally subjected to distillation in order to drive off the oil. This is such a costly procedure that under present conditions in this country, oil from shale rock is not a paying proposition. In Scotland, however, shale oil recovery is an industry of respectable proportions, competing successfully with overseas petroleum.

Recent advances in the design of gasoline engines have had fuel economy as the goal. It is quite possible that the engine of tomorrow will double the miles obtainable from a gallon of gasoline. This result can be accomplished by (1) increasing the compression of the fuel charge and (2) by increasing the average percentage

(*Continued on page 32*)

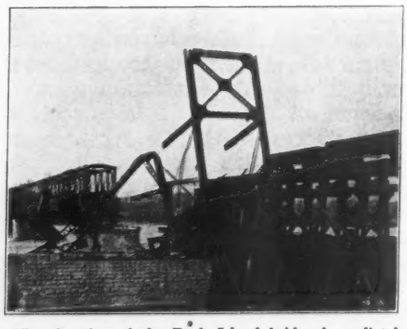
ALDRED LECTURES

SPECIAL PROBLEMS IN BRIDGE DESIGN AND CONSTRUCTION

By DOCTOR RALPH MODJESKI
Consulting Engineer

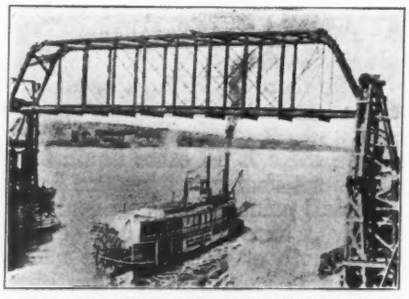
PRESIDENT STRATTON, in his introductory address to you, in which he pointed out the object of the Aldred Lectures, said that they are "Intended for giving students and graduate students an insight as to what is coming after the college course." There is no better way to give you such an insight than by having engineers of experience in the various branches tell you what they have encountered since graduating. It is true that by so doing the engineer of experience who addresses you may appear self-laudatory or may appear as setting himself up as an example to follow; but, as a matter of fact, he will only have in view whatever may be of benefit to you in his experience.

Indeed, much awaits you after the college course. As you will at first occupy a subordinate position, your entire efforts will no doubt be directed toward details — very minute details. As you will advance gradually to more responsible positions, your problems will broaden in scope and it will be your subordinate who will be occupied with the minute details. Your well practiced eye will then be able to



The situation of the Rock Island bridge immediately after the accident which destroyed a large part of the falsework, crumbled the traveler to pieces and carried away one of the towers already erected. Only twelve hours more would have saved the trusses.

detect at a glance any marked error in the subordinate's work. Thus you will learn to direct important construction, which is the real goal of an engineer. It will be then that the greatest problems will confront you — problems requiring sound judgment and unerring decisions based on experience and common sense. But "common



THE TEMPORARY LIFT SPAN ON THE ROCK ISLAND BRIDGE

Used to prevent the interruption of navigation and railway traffic during construction of the New Draw Span. As shown, it is lifted 16 feet. The maximum was 20 feet, 1 inch.

sense" in engineering must have a foundation in science and experience; it is another name for logic; it is all your years of study and all your years of experience boiled down to what might be called a sixth sense. Neither is it always possible to acquire it through study and experience alone — one must be born with the requisite qualities for attaining it. Nor is this sixth sense, with all its background of science and experience, sufficient for marked success in engineering. One must have also imagination, initiative, resourcefulness and perseverance.

Each branch of engineering, whether it be electrical, mechanical or civil, whether it be railroad, hydraulic or bridge engineering, offers frequently unusual problems which the engineer must solve. A bridge even of considerable size, if it presents no unusual problems, may be successfully built on almost standard lines by an engineer possessing only science and common sense. But where unusual problems arise, every attribute of the engineer may be called into action: common sense, imagination, initiative, resourcefulness and perseverance.

It may be of interest to you to review with me some of the problems, big and little, that have come up in my experience.

At the very start of my independent practice, as Chief Engineer of the Rock Island Bridge over the Mississippi River I was confronted with unusual problems. It was necessary to replace the then existing single track iron bridge with a heavier double track structure and utilize as much of the masonry piers as possible; and all this had to be done without interruption of railway traffic or of navigation. The bridge had a double deck, the railway floor being placed above the roadway floor. The clearance above the roadway was about twelve feet, so that the grade of the railway floor had to be raised two feet in the new bridge to provide for the increased depth of the double track floor beams. The bridge consisted of a 365-foot draw span, two 258-foot fixed spans and three 216-foot fixed spans. The draw span had to be erected in some way not to interfere with the traffic, and it was planned to do this work during the winter season when navigation would be closed. The erection of new fixed spans was simple enough, the old spans being supported on false work and dismantled; the change of two feet in grade was accomplished by raising one end of

THE DRAW SPAN OF THE ROCK ISLAND BRIDGE READY FOR SWINGING

Note the lift span to the right of the Pivot Pier and the falsework with the old floor system to the left

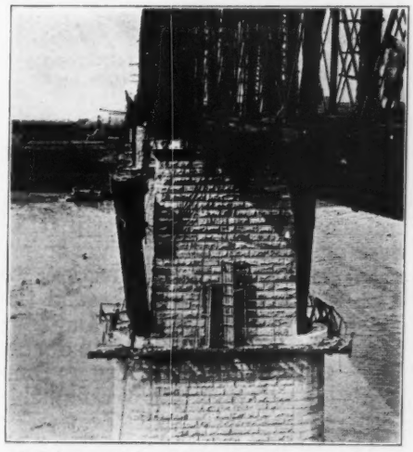
each old span to the new grade as the new span was erected, thus forming what might be called a progressive incline. The erection of the draw span did not go as well. Due to delay in receiving the material for the turn-

table, the erection of that span did not begin until February. The weather being very cold, the contractors on their own responsibility undertook to proceed with the erection of the river

After supporting these single track spans for forty-five years, the piers now carry a heavy new double track superstructure

arm of the draw span. During this period the trains were carried on false work only, the old drawspan having been removed. But on February 23, the river rose suddenly and the thermometer went up to forty degrees above zero. The river kept on rising and the situation was becoming more and more critical. In the meanwhile the contractors were pushing the erection of the river arm with desperate determination to close the half of the draw span before the ice went out. On February 25 the ice went out, carrying with it the falsework and steel thus far erected. Twelve hours more would have permitted the connecting of the arm to the pier, and twenty-four hours more would have seen the structure entirely safe. Here the main problem was how to shorten the inevitable time of interruption to the railway traffic, and how to provide for navigation by the time the season opened. The false work in the shore channel of the draw remained intact. We proceeded to replace the false work in the river channel, working day and night, and in five days the railway traffic was reëstablished. In about four weeks the navigation season was due to open. It was out of the question to replace the necessary steel and complete the erection in this short time. The resident engineer suggested building a temporary lift span. This suggestion was carried out in a rather amusing manner. The railway company happened to have a combination span on their road which could be spared. It was 147 feet, 5 inches long and fitted our problem very well. A temporary lifting device was designed. It had to be simple and easily constructed. Two timber towers were erected and the lift span put in operation on March 26, or one month and one day after the accident. This was none too early, as on March 27 the first boat passed through. It took one minute to raise and the same time to lower the span. The raising device consisted of steel rope and sheaves, without counterweight, operated by two hoisting engines, one near each end of the span. The operation was entirely successful, even beyond expectations. The motion of the span was very steady, and it came down on its bearings without the least shock. It remained in operation until May 24, when the new draw span, which was then erected on the draw protection or at right angles to the center line of the bridge, was swung into place. The lift span was operated at the average over fourteen times a day and as many as twenty-five times in a single day.

When the new draw span was ready for swinging into place, everything was prepared in advance to reduce the time of that operation to the minimum. It was one of the busiest days in my experience. The lift span was partly raised and suspended by proper



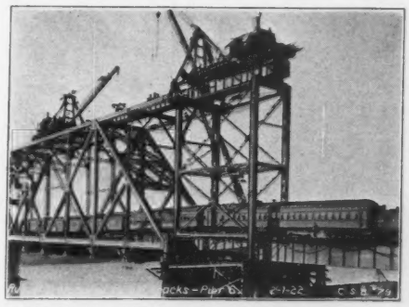
Erecting one of the steel columns used to strengthen the piers of the Cincinnati Bridge

rigging, the temporary towers were toppled over into the river and towed away. Three barges tied together were brought under the lift span which was then lowered onto them and towed away. At the same time the false work in the shore channel was removed by a specially constructed derrick car. When everything was thus cleared away, the new draw was swung into place. The actual time of interruption to navigation was twenty-four hours and twenty minutes, and to railway trains ten hours and thirty-five minutes.*

The more bridges there are nearing the end of their usefulness, either because of deterioration or because of increase in the weight of rolling stock, the more often problems arise of renewing or strengthening them under continuous traffic. The solution of such problems has become almost a science by itself. The circumstances under which such work is done are quite varied and the solutions often difficult and hazardous. Where the structures cross navigable waters the solution is often complicated by the necessity of keeping navigation open. This, as I have described, was the difficulty in Rock Island.

In the Bismarck Bridge over the Missouri River in North Dakota it was desired to replace the three four hundred-foot through-spans and two short deck-spans by new steel capable of carrying the increased power. The work was carried out on false work without difficulty. The old spans were removed and the new ones erected while traffic was carried on the timber falsework. The channel span was erected in winter during the period of closed navigation. The main problem there was one of efficient organization capable of carrying out the work quickly during the low water stage. and completing it before the ice broke up. It was for that reason that erection was not done by contract, but by authorization from the railway company to employ such and as many men as in my opinion would accomplish the desired result. The work was done without delaying a single train more than a few minutes.

At Keokuk, Iowa, there is a bridge over the Mississippi River, over which pass steam railroads, interurban cars, vehicles and pedestrians. In the old bridge, all this traffic was carried on one deck, and of course there was much interference and constant danger of accident. It was necessary to maintain all but the pedestrian traffic during reconstruction. The new bridge was designed so that the vehicular and pedestrian traffic would be accommodated on a separate deck placed above the railway deck. The work was completed without interruption to traffic of more than an hour or two at a time, and that occurred at stated times of day, so traffic could adjust itself to it. The vehicles were carried on the lower deck where the pavement was left undisturbed until the upper



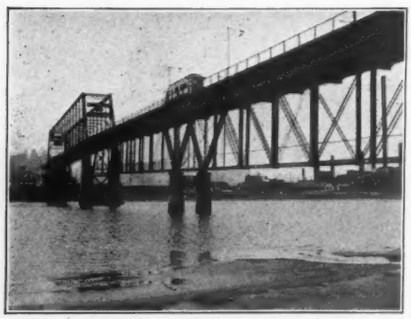
The Cincinnati Bridge in construction, showing the runoff from raised to old tracks

deck was ready to receive it. Falsework was used throughout. The draw span was erected during closed navigation.

About the most complicated and difficult case of renewing a bridge

* See Journal Western Society of Engineers, Vol, II. No. 2, April, 1897, paper entitled "Erection of Draw Span of the New Rock Island Bridge" by the author.

under traffic was in Cincinnati, Ohio. The Southern Railway Bridge there, over the Ohio River, built in 1876, was a single track structure, the river part of it consisting of two three hundred-foot spans, a channel span of 219 feet (then the longest simple span in existence), and a draw span 370 feet long. The loading on the bridge built so long ago was naturally restricted; the locomotives were limited to 65 tons and freight cars to 115,000 pounds gross weight. It became necessary not only to increase the capacity as to weight of rolling stock but also as to number of trains by building a double track structure. It was proposed to use the old piers in the new bridge. They were examined and found in excellent condition. It is rather remarkable that these piers, built of limestone and natural cement should have remained in service for forty-five years and then be found sound enough to carry the greatly increased load of a new steel superstructure. However, they were not long enough at the coping for the greater width between trusses which was to be 32 feet, 4 inches on centers; but below the starling they were 42 feet long and therefore this width could be carried to the top without adding anything to the piers below high water level. The starling copings were removed and the projections leveled off. To take care of the great concentrations, columns were placed on these projections on which columns the end bearings of the spans were to rest. To distribute the load more equally, these columns were placed closer together at the bottom than the distance between trusses, making them lean outward at the top. They were connected at the top by heavy girders which were made to transmit part of the superstructure load to the center of the pier by wedging and which were then concreted in. In this manner the weight of the new



STREET RAILWAY BRIDGE OVER THE MISSOURI RIVER AT OMAHA

steel and of the heavy traffic is well distributed over the entire area of the pier and foundation. The columns were hooped with steel reinforcing rods which also tied them to the body of the pier. Rods and columns were then encased in concrete.

The War Department stipulated that no falsework be placed under the 519-foot channel span or under the adjoining 300-foot span. This meant cantilever erection. The clearance above water must remain the same as in the past, but since the floor of the

ONE OF THE CHANNELS AT LOW WATER COLUMBIA RIVER, CELILO, OREGON

double track bridge is four feet deeper than the old floor the grade on the bridge had to be raised correspondingly.

And so the given conditions of the problem were to dispense with falsework under the two main river spans, which meant cantilever erection; to erect the new steel work around the old spans; to raise the grade four feet; to change the single track into double track; to remove the old trusses from inside the new ones and to do all this without interruption to traffic.

The condition of dispensing with falsework was met by designing the spans as a continuous structure over four supports which permitted the trusses to be erected by cantilever method. This method required that the erection equipment be placed on top of the trusses. The track for this equipment was built of stringers which were later to support the permanent tracks of the bridge. These stringers were carried on the sway bracing of the new trusses, and advanced panel by panel as the erection progressed. The material for the new trusses was handled on a track outside the trusses and supported on specially constructed brackets. The raising of grade was accomplished by first suspending the new floor beams four feet below the final level, in this manner supporting the old spans previous to dismantling them. As the old spans were removed the new floor beams with two lines of stringers were raised to their final position. A movable ramp or incline was used to make the transition from the new grade to the old.

Since the stresses in a continuous structure are largely dependent on the reactions at the supports, these reactions were carefully adjusted by powerful jacks, and the resulting stresses verified by extensometer measurements.

Thus summing up, the piers were prepared for the columns and the columns set before the erection of the new spans was started. The new trusses were then assembled outside with their sway bracing between the members of the old spans by cantilever method proceeding from both ends. The closure was made at the center of the 519-foot span. The floor of the new trusses was placed temporarily below the old floor. The old trusses were then removed from inside the new spans, the new floor raised into its final position, and both new tracks completed.

It was quite another problem at Poughkeepsie. There the bridge owned by the Central New England Railway consisted of a cantilever deck structure of five main river spans, each over 500 feet in length and two anchor arms. It was first built for double tracks with only two trusses. Later a third line of trusses was added in the center. Even that was not sufficient to accommodate the ever growing size and weight of locomotives. About eihgt years ago I was asked to see what could be done to convert this bridge into a single track structure, and to make its capacity equal to carrying the heaviest modern motive power. The combined strength of the three trusses was sufficient, but the load from a track placed over the center truss had to be distributed equally to the three trusses as they were of about equal strength. New floor beams and a double line of new stringers were ordered to replace the old floor system. These floor beams were made strong enough for a double track heavy power and were of one piece over the three trusses. The stringers also were proportioned for heavy power. The floor beams distribute the load practically in the direct ratio to the resistance of these trusses, since the deflections are equal in each truss, being controlled by the

THE PIERS FOR THE CELILO BRIDGE AT HIGH WATER
The islands are completely submerged

stiffness of the floor beams. The action is similar to that of a plank on a spring mattress. Here, also, the changing of the floor was done without stopping traffic excepting for the time necessary

to change a panel or two of the floor from old to new. This operation of changing was so well organized that the interference with traffic was insignificant. It is intended to utilize the

BASALTIC ISLANDS IN THE COLUMBIA RIVER AT LOW WATER
Note the spans for the Celilo Bridge are all of equal length

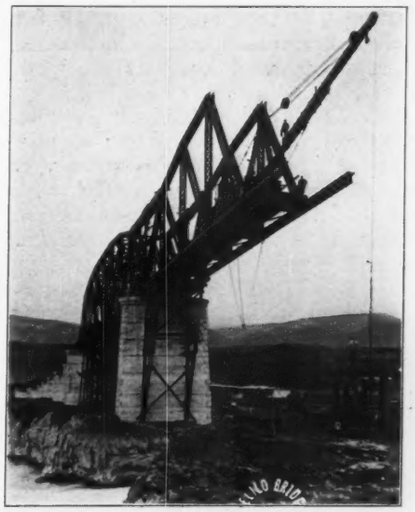
double track floor beams when it becomes necessary to rebuild the bridge for double tracks.

There seems to be no limit to the progressive increase in the weight of locomotives and therefore problems of strengthening existing structures will become more and more frequent, and those of you who may embrace bridge building as a profession will be confronted by them more often than by the construction of new bridges.

But not only railway bridges are being reinforced. With the event of automobiles and motor trucks, the highway traffic is constantly growing, calling for more capacity in bridges.

The street railway bridge over the Missouri River at Omaha is now under reconstruction to double its capacity. A new line of cylinder piers was built for that purpose, and one line of the old trusses will be placed on them at about twice the former distance from the other line. New trusses will be inserted in the center. This will provide two roadways instead of one. But the old trusses are now not quite strong enough to safely carry one-half of the roadway loads which in recent years have greatly increased. Instead of strengthening them, which would be an expensive and laborious operation, the center truss is made heavy enough to take care of the efficiency in strength of the old trusses besides the loading carried directly by it. The sway bracing is made strong enough to transmit part of the load from the outside trusses to the center truss. Thus any tendency of one of the outside trusses to deflect more than the other two is checked by the sway system, which, resting on the center truss as a fulcrum, exerts a lifting effort on the other outside truss. To make this action uniform and consistent the new trusses are designed as nearly as possible like the old ones as to system of trussing and depth. In this bridge, then, the loads are distributed among the three trusses just as they are in the Poughkeepsie Bridge, with the difference that in Poughkeepsie the distributing members are the floor beams and in Omaha the sway bracing. In such problems of strengthening, especially when one or more trusses are added, it is necessary not to lose sight of the principle that trusses or girders of a given design as to length, depth, paneling, etc., but of different strength, will deflect under a given load in an inverse ratio to their strength. Or, if by proper distributing members their deflections are caused to be alike panel by panel, the total stresses in the corresponding members of the different trusses will be in direct ratio to their working sections.

The foregoing instances refer to difficulties arising from the necessity

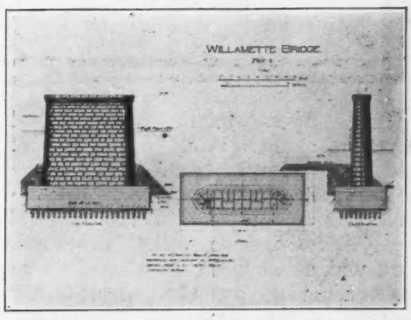


THE CELILO BRIDGE IN CONSTRUCTION

of keeping traffic open on or under existing structures.

There are other unusual problems of a different and most varied nature which are apt to present themselves.

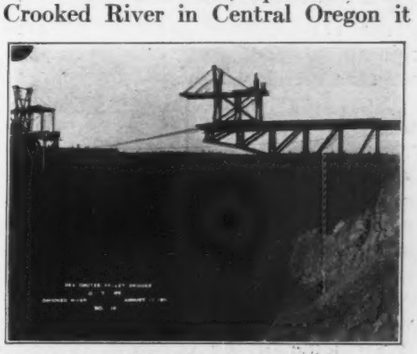
When it was decided to build a single track railway bridge at or near Celilo, Oregon, across the Columbia River, several locations were considered. The one selected crossed the river at a place where the river narrows to about 2700 feet at high water. At low water the bed of the river consists of a number of basaltic islands separated by channels of rushing, foaming water. The main channel near the Oregon shore is about 300 feet wide, while the other channels vary in width and are quite narrow, some of them drying up entirely at low water. At high water all those islands are submerged. The location finally selected, after a number of trials, was such as to place all of the piers on exposed rock, and yet make all river spans, excepting the one over the 300-foot channel, of equal length. There were six spans of 240 feet and a number of plate girders in the approach. Thus it was possible to build all foundations of the nine main piers and a number



DRAWING OF THE PIER BUILT ON PILES
The pier sunk about four inches after being completed. Note the rip-rap to prevent further leaning to the shore.

of smaller ones in the open without cofferdams, and they have the unusual advantage that they can be inspected at low water. It may be more correct to say that the basaltic islands are the real foundations and that the location and arrangement of spans made it possible to utilize them. Because of the channels between the islands, it would not have been possible to build timber falsework beyond the first spans. The other spans were erected by cantilever method — all adjusting devices being used over and over again.

The solution of minor problems is sometimes even more interesting than of the larger ones. Some of them even lead to subsequent general change in practice. Those of you who are familiar with the method which was employed for closing the two-hinged arch at Niagara Falls for the Grand Trunk Railway will remember that it was necessary to introduce stresses in the center members by artificial means before the closing was effected. This was an expensive and tedious, and in a measure uncertain, operation. At Crooked River in Central Oregon it



BRIDGE OVER THE CROOKED RIVER IN PROCESS OF CONSTRUCTION
When completed, the trusses acted as three-hinged frames for dead load, and as two-hinged frames for live load

was decided best to build a two-hinged arch of 340-foot span. The walls of the canyon are almost perpendicular and the track is 350 feet

(*Continued on page 30*)

MONTHLY NEWS

The Spectrograph for Metal Analysis. Increasing numbers of industries engaged in the manufacture of metal products are finding a valuable aid in the method of spectral analysis of metals which they use, and which has been developed to its present state by the spectroscopy section of the Bureau of Standards. This system offers a more convenient and rapid means of detecting impurities in metals than chemical methods.

It was while the Bureau of Standards was engaged in researches in this science that a problem came up. A steamship had been lost by a boiler explosion. In such boilers there had been placed a safety plug which was supposed to melt at certain temperatures forming one of the conditions preceding such an explosive point. The "safety plug" had apparently failed. "Why" the Bureau was asked.

The spectrograph revealed that plugs which were supposed to be of pure tin contained a trace of lead, zinc, and other metals in some cases. Pure tin melts at a temperature of 232 degrees, Centigrade. The presence of lead or zinc or other impurities caused the formation of a compound which required a very high temperature for melting. Hence the spectrum analysis had been applied in a rapid and convenient manner, and an optical method could supplant a more complicated chemical test. In the case of a mid-western manufacturer whose factory made high pressure valves, leaks were discovered. The spectrograph revealed the presence of aluminum in the alloy — in a degree unfavorable to high pressure work.

Not long ago the spectrographic method revealed its accuracy in "checking up" the Bureau of Standards itself. Standard samples of vanadium steel had been prepared and sent to various points. Word began to come back that these "standards" showed traces of tin. At once an exhaustive check-up was begun. The operations were carried on to the point of boiling down some of the chemical reagents used in preparation of the samples. A tiny scrap of residue was found, not larger than the head of a pin, too small for chemical analysis. Use of the spectrograph disclosed that there were eleven chemical elements in this tiny speck, and that the most prominent was tin.

In preparing purity standards of platinum, rhodium, iridium and palladium, the spectrograph has again been used with success, and it is declared that the chemical knowledge of these unusual metals is as yet so unsatisfactory that this method is the only safeguard.

New Water-Cooled, High Voltage, X-ray Tube. A new water-cooled, high voltage X-ray tube has been perfected by Dr. W. D. Coolidge of the General Electric research laboratories. The tube operates at 250,000 volts, 50 milliamperes, and has an X-ray output of about fifteen times that of the old style tubes.

Radiation from X-ray tubes has for some years been used in the treatment of cancer. The early tubes were of comparatively low output, their successful use being restricted to tumors not too deeply seated. The original Coolidge tube operated at a voltage of 200,000 volts. Because it gave radiations of shorter wave length and consequently greater penetration it was better adapted for the treatment of deep-seated cancer. This tube was further improved by an anode or target made of a large flat plate of tungsten with sufficient surface to radiate continuously the energy absorbed when the tube was operated at 30 milliamperes and 200,000 volts. This tube was operated in an oil bath which was water-cooled

The final step was the production of a still more powerful tube. This tube is equipped with a water-cooled anode, a seamless metal tube being utilized to conduct the water in and out of the X-ray tube, the solder between tubing and target being depended on only for making thermal contact. The glass bulb is eight inches in diameter. The tube is operated in conjunction with a generating outfit consisting essentially of a high-tension transformer, rectifying switch and resistance control. An insulated water system is used in cooling the tube. By means of this tube the time required for the treatment of the cases has been diminished materially, and it has met with marked success at the Battle Creek Sanitarium.

One Hundred and Fifty-Seven Railroads Use Motor Coaches. While only 40 railroads were listed last year as operating motor rail coaches, a compilation made on January 1, 1924, shows a total of 157, or an apparent increase of about 400 per cent. These figures indicate that the railroads of the country are not only using the motor coach in an experimental way, but many of them have already found that it is practical and economical.

Among the latter may be numbered the New York, New Haven & Hartford Railroad. It began a test of the motor rail coach about two years ago. Three motor rail coaches, each accommodating 30 persons and providing space for 1,000 pounds of baggage, were placed in the service. As a result of the success of this venture, a larger type of gasoline propelled vehicle, providing accommodations for 60 passengers and 2,000 pounds of baggage, was also placed in service. This is propelled by a 120 horse power 6-cylinder motor. This larger unit has so proved its worth that the New Haven road has recently ordered 10 new units of the same type.

A significant experiment with another high-powered motor coach was begun recently by the Canadian National Railroad. This new rail motor coach is driven by a 225 horse power gasoline engine, seats 55 passengers and has a baggage compartment 15 feet, 2 inches long. The coach has a steel body differing from most rail motor coaches which generally have bodies built on a standard motor bus style. The car weighs between 40,000 and 45,000 pounds.

The Dominion Government has commenced the erection of a wireless plant in connection with the Royal Canadian Air Force, at Jericho Beach, Vancouver, B. C. The towers will be of fabricated steel, 100 feet high and 300 feet apart, and will be erected by the Royal Canadian Engineers. The plant will be equipped with wireless and radio sending and receiving apparatus, and will be sufficiently powerful to communicate with the plant at High River, Alberta, 500 miles to the east, whence messages can be relayed to eastern Canada. The airplanes and seaplanes at Jericho Beach will be equipped with radio receiving sets, which will enable the airmen to keep in touch with their base during flight.

Scout Cruiser Completes Official Trials. The United States scout cruiser *Raleigh*, built by the Bethlehem Shipbuilding Corporation at Quincy, is the most modern vessel of her type afloat. In her trials she excelled her sister ship, the *Detroit*, which was delivered to the Navy a short time ago.

The *Raleigh* is 550 feet in length with a breadth of 55 feet and a displacement of 7,200 tons. She carries twelve 6-inch rapid fire guns of the very latest model, four 3-inch anti-aircraft guns, capable of firing into the air at any angle up to 90 degrees. She also carries 10 torpedo tubes and 200 mines which can be launched in a very few minutes. This vessel is fitted to carry airplanes which can be launched from a revolving catapult while running either with or against the wind. She is also equipped with high power radio apparatus, wireless telephone, submarine signalling and electric steering gear; she also has a fully equipped hospital, laundry, workshops, etc.

The propeller machinery developed 100,000 shaft horse power on her trial which is sufficient to drive the vessel at a speed of forty-one statute miles per hour. The main propelling machinery consists of twelve oil-fired watertube express type boilers operated under forced draft and three being placed in each of the four watertight compartments. There are two watertight engine room compartments located amidships in which are located the main Curtis type marine turbines, which operate at a speed of 2,500 r. p. m. which is reduced through reduction gears on each of the four propeller shafts to a speed of 400 r. p. m.

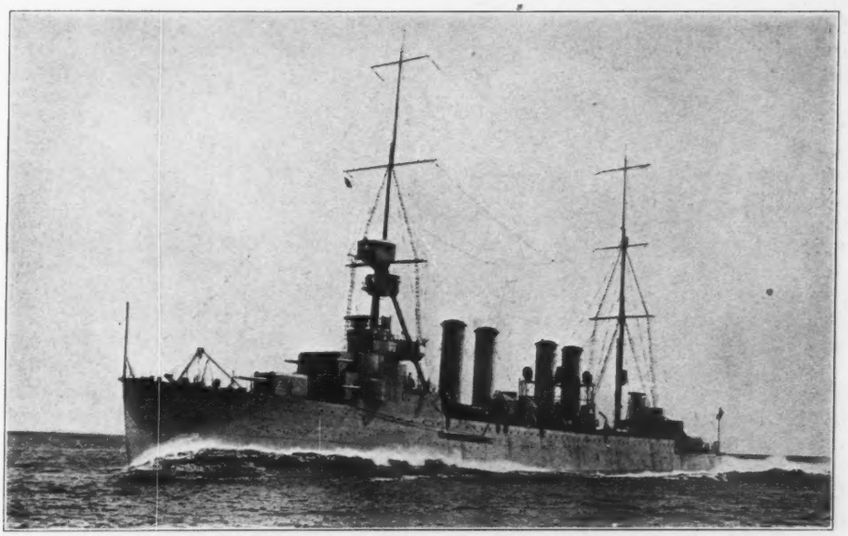
Steam is generated at a rate of 1,005,000 pounds per hour with a pressure of 265 pounds per square inch. The four main condensers require 70,000,000 pounds of sea water per hour to condense the exhaust steam from the turbines. At full speed the boilers will consume about 100,000 pounds of oil per hour.

— *Marine Engineering*

New Gauge Records Impact Strains. The recording of strains produced in bridges by trains or motor trucks passing over them has been made possible by a new electric telemeter of strain gauge developed at the Bureau of Standards. The gauge has two points which are clamped to the part of the bridge truss on which the measurements are to be made, and two stacks of carbon discs. A change of load on the truss causes a change in the distance between these points, and this is arranged to cause a change in the pressure on the carbon stacks and a consequent change in their resistance. The electrical apparatus for measuring and recording these changes can be placed at any convenient point, being connected to the gauge by three wires, and the apparatus can be made to record very rapid changes. The recording apparatus can be used with several gauges at once, as many as twelve gauges having been so used with a single recorder.

The problem of recording these instantaneous strains has never before been successfully solved, although their values were known to be high. A heavy motor truck running over a rough floor, or a locomotive going at high speed, may cause a strain on a bridge truss very much greater than would be caused by the same machine when not in motion. Similar problems occur in the case of aircraft and the new strain gauge can also be used to measure the strains produced in them while in flight. Sixty such gauges were used in the tests of the *Shenandoah* and the data secured by their aid is expected to prove of great value in the design of airships in the future. The gauge has also proved of value in the laboratory testing of structural materials when a great many strain measurements have to be made.

New British Submarine Fastest, Biggest in World. The submarine X-1, which is nearing completion at a Chatham dockyard for the British Navy, will be the longest as well as the fastest submersible craft in the world. She will have a surface speed of thirty-three knots, thus enabling her to accompany battleships when steaming at full speed. The submarine will carry six 5.5-inch guns, an armament said to be unique for an under-sea craft. Her displacement will be 3,500 tons. It is recalled that the first British submarine, built in 1901, displaced 120 tons and had a surface speed of nine knots.



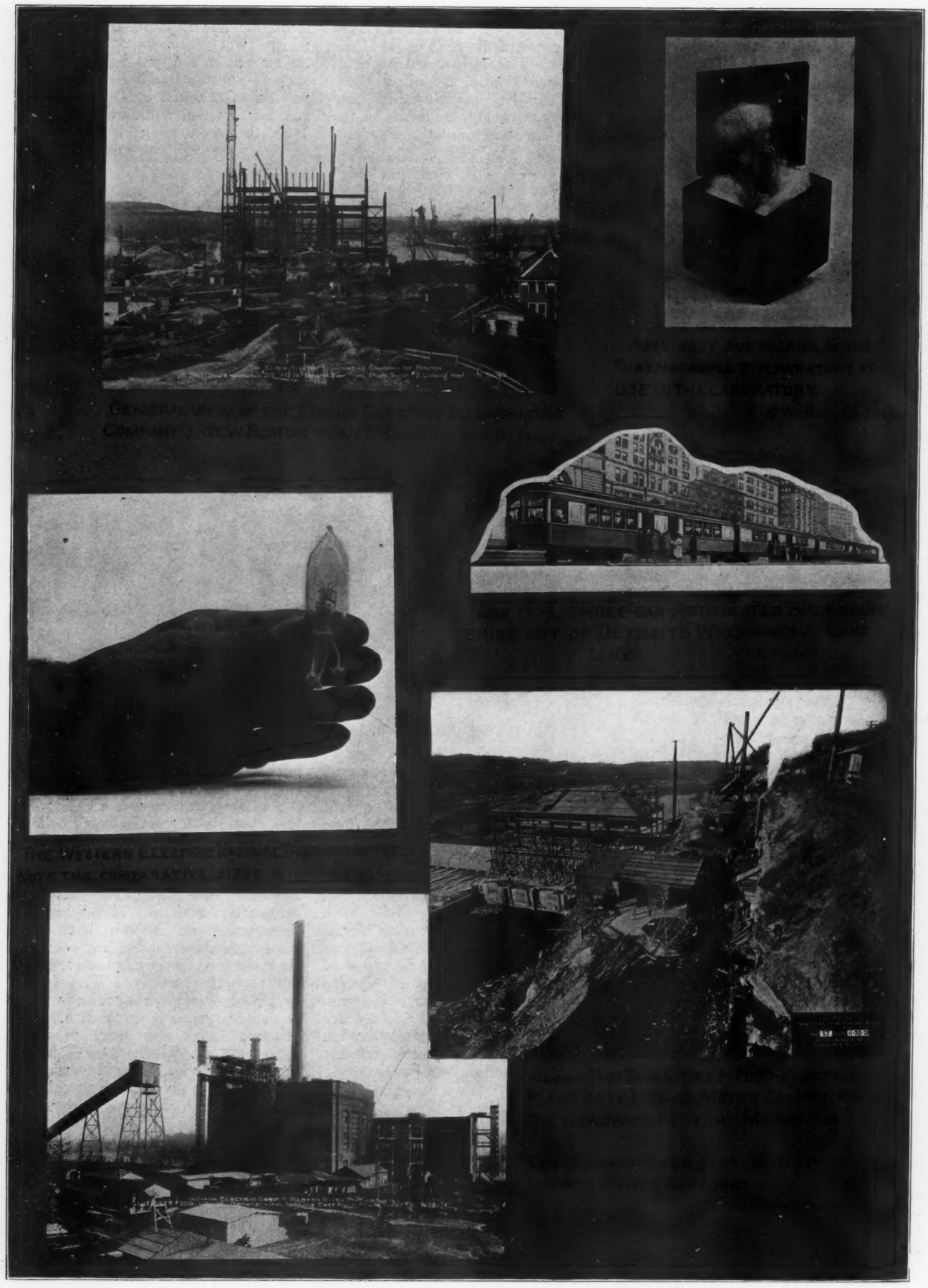
THE SCOUT CRUISER RALEIGH ON HER OFFICIAL TRIAL TRIP

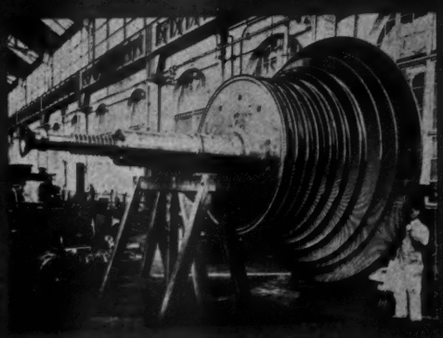
BOOK REVIEW

Principles and Practice of surveying, Volume I, Elementary Surveying. By Charles B. Breed and George L. Hosmer. John Wiley & Sons, Inc., New York, 1923. Flexible covers, pocket size, 592 pages, tables, illustrations, $4.00. Fifth edition.

The authors have taken their work, the standby of practically all colleges and universities where civil engineering is taught, and brought it up to date. The chapter on "Observations for Meridian and Latitude" has been completely revised. The tables for observation on Polaris have been improved. More stress has been put on the most frequently used methods and the others left out. The chapter on City Surveying has been re-written in order to bring it up to date. Some changes have also been made in Chapter XLV. The method of dealing with traverses by means of rectangular coördinates is given more prominence and balancing of surveys treated in greater detail.

The popularity of the Breed and Hosmer texts on surveying testifies to their worth. They are used in engineering colleges all over the country. The flexible binding in a pocket size makes the volume convenient to use in the field, as well as in the classroom and office.

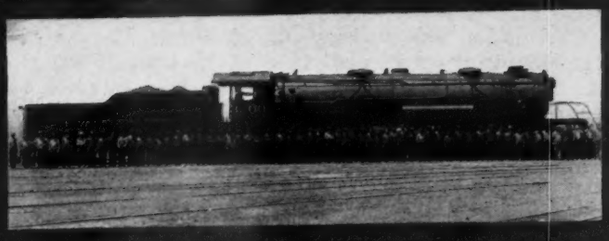




HUGE ROTOR FOR A 40,000 KW. 1800 R.P.M. STEAM TURBO-GENERATOR.

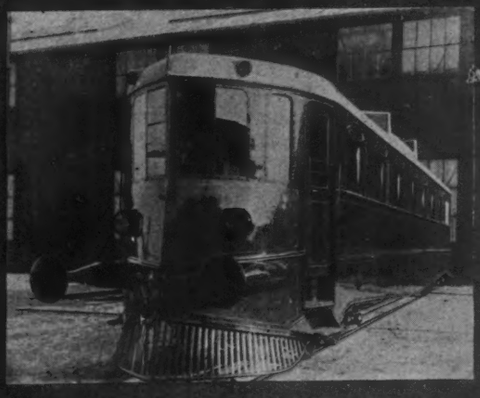
Wide World Photo

BIRDS EYE VIEW OF THE WILSON DAM, A PART OF THE MUSCLE SHOALS DEVELOPMENT.



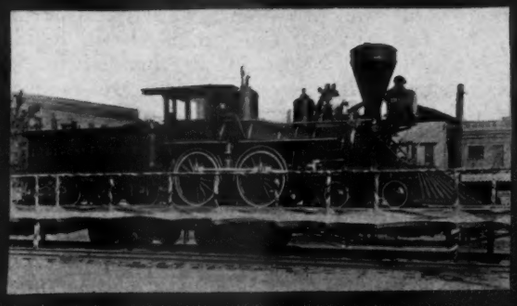
372 TON MALLET TYPE LOCOMOTIVE DESIGNED FOR FREIGHT SERVICE IN THE ROCKY MOUNTAINS.

Wide World Photo



A GERMAN TROLLEY CAR WHICH IS PROPELLED BY THE RECENTLY DISCOVERED "SUCTION GAS"

Wide World Photo



A COMPARISON OF THE WOOD FIRED ENGINE, WILLIAM CROOKS, ONE OF THE FIRST ENGINES PLACED IN SERVICE ON THE GREAT NORTHERN RAILROAD AND ONE OF THE NEW OIL BURNING LOCOMOTIVES. THIS TYPE IS THE HEAVIEST TYPE OF PASSENGER LOCOMOTIVE IN SERVICE.

Wide World Photo

A 1,100,000 CANDLEPOWER SEARCHLIGHT, CAPABLE OF SENDING A BEAM OF LIGHT ONE HUNDRED MILES

Wide World Photo

EDITORIALS

OIL

After having one's eyes and ears filled with the many ramifications of the so-called "Teapot Dome Scandal" and the impression it has created concerning the laxness and possible criminal waste on the part of certain government officials, it is of interest to note in a short comment in the current issue of *Marine Engineering and Shipping Age*, that at least one governmental agency is effecting a very substantial saving of oil.

This agency is a department of the Shipping Board and the comment on its work is given here in part. "We believe it to be the unanimous opinion of such competent engineers as are familiar with the subject, that the work of the Fuel Conservation Section of the Emergency Fleet Corporation is of far reaching importance and of great value, not only to the government, but to private shipowners and operators as well.

Called into being as a result of the irregular and generally unsatisfactory engineering operation of many Shipping Board vessels, the Fuel Conservation Committee, consisting of both Shipping Board and outside engineers of recognized standing, was organized in July, 1922. This committee, working through the Fuel Conservation Section of the Emergency Fleet Corporation, has determined standards of performance for all classes of Shipping Board vessels; established ratings for engineers as determined by the performance of their vessels in comparison with these standards, and furthermore, has established effective means of training engineers in the use of oil fuel and of correcting defects on such ships as show unsatisfactory performance and excessive fuel consumption.

The effect of the work of the Fuel Conservation Committee became almost immediately apparent in improved performance of Shipping Board vessels, and the absolute saving in fuel, brought about by the establishment of the standards of efficiency for the various vessels, has already reached a surprising total.

The work of the Fuel Conservation Committee and Section was first brought to the general attention of engineers and ship operators by a paper read before the Society of Naval Architects and Marine Engineers in November, 1923, by Joseph E. Sheedy, vice-president of the Emergency Fleet Corporation. It has evoked most favorable comment, both here and abroad."

ENGINEERING EDUCATION

We print on another page an article by Prof. A. G. Christie of Johns Hopkins University concerning engineering education. As Professor Christie says, the subject is one which has been discussed many times by many persons.

The main interest hinges on the plan, now being tried at Johns Hopkins, of having a combined Arts and Engineering Course, extending over a period of six years, a plan resulting probably from the often expressed idea that the engineer has very little cultural training, that he is too narrow. It also tends more towards the practice followed in the two professions of Law and Medicine where an A.B. degree is required before the specialized work is begun in earnest. It is a step toward making engineering schools entirely graduate schools, where every man attending has already obtained an A.B. degree.

Undoubtedly this plan is the forerunner of many similar ones and from the viewpoint of Technology it is well worth thorough consideration. Many men here realize, after they have gone too far to change, that they are not interested in the particular brand of engineering in which they are specializing. In other words, they realize that their choice has not been a wise one. Immaturity of judgment and lack of experience are two of the major reasons for the frequent errors which occur.

The requirement of an A.B. degree for admission would throw out the first of these reasons and might conceivably affect the other, and the whole effect would be to eliminate those who are not in the place they belong; thus removing the burden of uninterested students from the instructors, and also from the students who have the interest and ability to enable them to proceed more rapidly.

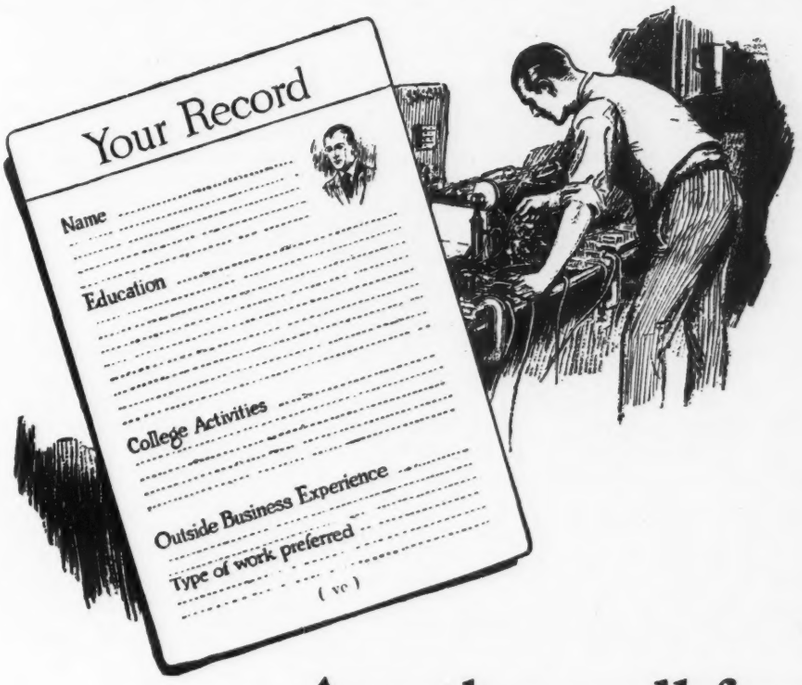
STANDARDIZATION

The question of standardization has been mentioned recently in these columns, but from an entirely different viewpoint from that which follows.

The former editorial gave the belief of Dr. Charles Eliot, president emeritus of Harvard University, that standardization was harmful in the extreme to progress, both in education and industry. This may be true at arts colleges, of which Harvard is one, but here at Technology where every minute counts, it is a question whether it would not be better to have more standardization in instruction, particularly with reference to the methods of grading in the various subjects. To elaborate — at present each professor in a department has his own ideas concerning the value of certain phases of the work in a particular subject. This is very noticeable in the places where the same subject is given by several different professors all of whom are in the same department. One professor will require all problems to be handed in on the day for which they are assigned, he will correct the problems, have the students correct those that are wrong, and return them to him. Such a professor evidently bases the student's final mark to a great extent, on his problem work. At the other extreme is the professor who assigns problems, but does not require the student to hand them in at all. He evidently bases the final grade entirely on the examination at the end of the course. And between these extreme cases are found many and varied systems.

Under such conditions it is very hard for a student to plan his work to best advantage. He does not know whether to spend most of his time on the problems as they are assigned, or to save the time until just before the final examination, and then study the course as a whole, until he has learned the method of the particular instructor under whom he has the course.

This is only one example drawn from the many cases of divergence now in effect. Some one method, not too stringent, but allowing of certain variations, might help the students and the faculty both. We wonder if it could be tried.



Another call for candidates

in this season of try-outs, seniors will do well to respond to the call for candidates which progressive business organizations are making.

The visit of the various company representatives offers a mutual opportunity. It puts you in position to judge whether a particular company offers sufficient scope to your ability and ambition. The representative can judge, after conversing with you and studying your record, whether you would be well placed in his company.

Do not ignore the invitation to these interviews. Do not be one of those—and they are many—who next Fall will write to the larger companies, "At the time your representative visited my college I did not think that I was interested in the work of your company and so did not meet him".

Men who are earnest in wanting to make the team usually respond to first call

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FORESTERS AND ENGINEERS

(*Continued from page 13*)

tive humidity, temperature and evaporation. Weather predictions covering these factors are therefore helpful in planning the fire protection organization. In the West, advantage has been taken of aeroplanes and radio in fire protection work. The aeroplane makes an effective, rapidly moving outlook, from which fires can be definitely located, by an observer who knows the country. The radio in connection with the aeroplane permits the transmittal of this information to a point where men and tools can be dispatched to fight the fire. In the West, lightning is responsible for the setting of a large portion of the fires. Further study of the relation between atmospheric electricity and the static, which can be detected by radio, seems to promise a means of predicting the approach of lightning storms in time to take measures for the control of many fires which may be started. Static has also been suggested as an index of changes in atmospheric humidity, which could be used to great advantage in the prediction of changes of fire hazard.

Much has been written about the relation between forests and water. On the deep soiled mountain slopes of the Appalachian Mountains it is well established that the removal of forest cover results in floods, due in part at least to the damming up of the stream beds by the débris from logging. As these temporary dams break, flood conditions recur and serious erosion takes place which has resulted in the silting up of reservoirs further down the valleys in surprisingly short periods. In the hard rock and comparatively level northeastern Lake States regions, where there is abundant precipitation, the stream flow is much less influenced by forest conditions. In the western mountains, however, the forest cover assumes major importance. An experiment which is being conducted by the Fremont Forest Experiment Station of the Forest Service in coöperation with the Weather Bureau is designed to determine by measurements of two similar water sheds, the difference in run-off and silting-up of dams with and without forest cover. So far the experiment seems to indicate that removal of the forest results in advancing the date of the flood in the spring, in increasing the height of the crest of the flood and in increasing many fold the amount of material washed down by the stream.

In the Lake States extensive swamps have been deeply drained with the idea of converting them to profitable agricultural lands. It is still uncertain how valuable much of this drained swamp land may be for this purpose. No further proof is needed, however, that the drainage results in the death of the trees and in disastrous fires in seasons when the peat becomes thoroughly dry for a considerable depth. In the northern European countries it has been found that the naturally slow growth of swamp forests can be greatly increased by moderate drainage. It is known that our northern swamp forests in this country grow very slowly. Can the growth be increased, and just what degree of drainage will be most effective for that purpose? This is one of the important problems which the Lake States Forest Experiment Station plans to study.

Forestry enters the field of zoölogy in the various ways in which animal life affects the forests. The grazing of cattle and sheep is sometimes a serious factor in the establishment of a natural young growth of forests. Control measures have had to be adopted to reduce the damage done by porcupines and rabbits. Rodents and birds of many kinds are a serious detriment to the natural regeneration of the forest because they consume enormous quantities of the seed of forest trees. Their appetites for seed have made direct seeding for purposes of reforestation impracticable in many parts of the United States because they devour the seed almost as fast as it is sown. Insects each year take a tremendous toll from the forests; witness the havoc wrought by the spruce budworm in eastern Canada and the adjacent United States, or the practical destruction of the merchantable tamarack in the Lake States a few years ago.

Botany has more and closer contacts with forestry than any other science. The laws of photosynthesis and of the water and food relations of plants as brought out in the study of plant physiology are equally applicable to forest trees. An understanding of them by the forester is essential to his understanding of the forests themselves. Matters of wood structure and the identification of woods and of plants, are, after all, the applications of botany to the trees. The many and sometimes serious diseases of trees due to fungi, such as the chestnut blight and the white pine blister rust, are other phases of the application of botany to forestry. Then, too, plant breeding offers a promising and as yet almost unexplored field by which the forester may improve his timber crops.

Finally forestry itself takes the materials from all these sciences and combines with them a special study of the development and complete life history of the forests themselves, not as assemblages of individual trees, but as communities which differ from individuals in the same way that human communities are more than mere aggregations of people. The trees in a forest have many and complex relations, one to another and to their environment, which require special study in order that their development may be modified or controlled to the greatest advantage of the owner. The purpose of the modification may be æsthetic, it may aim to change the composition to secure a larger portion of more valuable species, it may attempt to increase the rate of growth or it may be designed to secure timber of special quality. At the same time, forestry implies the application of the control of the development of the forests under a plan which will provide for the current replacement by young growth of the mature crop which is cut, so that any given forest area may produce annually or periodically a regular and sustained yield.

OSCILLOGRAPH

(*Continued from page 15*)

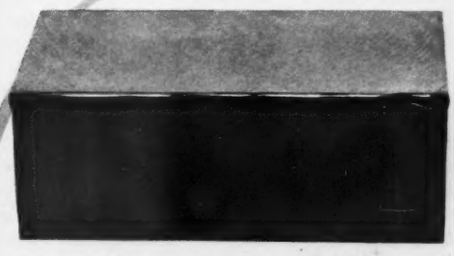
vary uniformly from zero to a maximum as the voice voltage moves from one extreme of its cycle to the other. Figure 1 shows this condition, or one hundred per cent modulation. Figure 2 shows a lower amount, corresponding to a softer passage in the music. Figure 3 shows over-modulation, which happens when some ambitious operator "crowds" this transmitter in a try for some new distance record. Over-modulation means distortion and dissatisfaction from his regular near-by audience.

The chief value of this cathode ray oscillograph is to get quick visible indications of what is going on in an electric circuit. It can therefore be used to explore a situation and ascertain roughly what is going on as a first step to devising measurements which will be more accurate. For example, after the apparatus is set up hysteresis loops can be taken very rapidly on one sample after another as against a half day each by the more accurate "point-by-point" method. Also for demonstrations before classes up to about twenty persons, this device shows what is happening with a clearness that is most convincing.

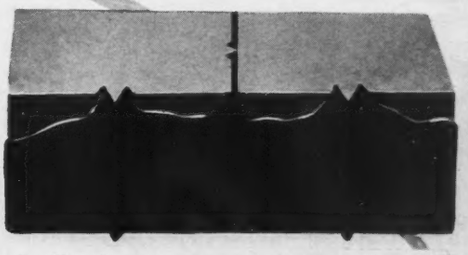
The last of the Aldred Lectures will appear in the May issue

KREOLITE KOUNTERSUNK - LUG - BLOCKS

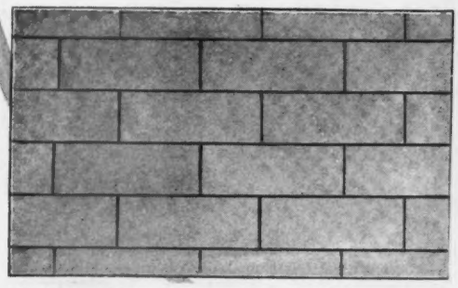
"The Paving that's Saving"



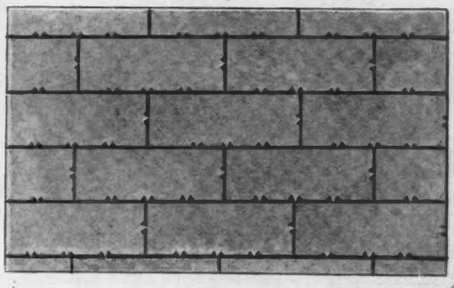
1—Showing imperfect penetration of filler with common rectangular block.



3—Showing nearly perfect penetration of filler with Kreolite Kountersunk Lug Blocks.



2—Plan view of plain or common rectangular blocks.



4—Plan view of Kreolite Kountersunk Lug Blocks.

KREOLITE Kountersunk Lug Wood Blocks are designed for bridge and street paving, and, with a slight variation of the kountersunk feature, for interior factory flooring.

This method of construction permits the penetration of the bituminous filler the entire depth of the block on all sides (see figure 3) securely binding it to the base and making a firm waterproof joint. The filler (our special make) is applied hot in liquid form and hardens when cool. The block cannot become loose because it is firmly attached to the base and to the adjacent blocks on four sides. In laying, only the tough end grain is exposed to wear.

In figure 2, the blocks make a good appearance, but is another case where beauty is only skin deep. The filler solidifies and fills only the upper part of the joint (see figure 1). Note bonding power, so essential to the permanence of any block pavement, as shown in figure 4.

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COPPER IN MODERN STEELS

(*Continued from page 9*)

pen points and boiler plates alike involve metal whose external surfaces are called upon to withstand widely varying agents of attack. Thus it is plausible to believe that factors which enable a steel to hold out well under one set of conditions may not be sufficiently important or even the same ones which govern its behavior under other circumstances. Copper may be influential in lowering a steel's susceptibility to rusting in moist air for one reason and may be responsible for entirely different characteristics which in another case render a steel resistant to acids. Yet copper is answerable for both natures of the steel's resistance. Be these numerous complications such as they may, it is interesting temporarily to close one's eyes to the details of the problem and to notice merely the effects of their summation, for these integrated characteristics are themselves the records which are to be found in the notebooks of industry.

While other qualities inherent in copper steels make their application to certain uses very desirable, their resistance to corrosion in all cases enhances and in some instances determines their usefulness. Notable has been the reaction of copper steel to the action of the atmosphere, whether the latter be of an especially acid nature as is found in the neighborhood of industrial centers, whether of the particular quality peculiar to sea coast localities or of a comparatively pure character as is found in mid-continental agricultural regions. Copper bearing sheeting in all of these media and weather conditions has long outlasted their non copper analogues.

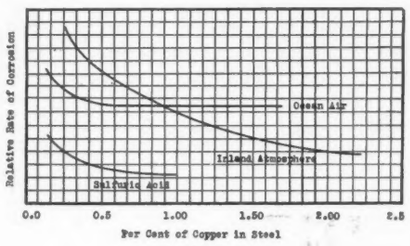


FIGURE 10
EFFECT OF COPPER ON THE RATE OF CORROSION OF STEELS

Gondola and hopper cars constructed of alternate plates of copper and non copper steels have demonstrated the ultimate superiority of the former type of steel to the combined agents of erosion, corrosion and abrasion. Rails have been made of copper steel for many years and have met the corrosion problem in as effective a way as they have answered other physical requirements. Structures of copper bearing steel corrode to produce smoother rust coatings than do steels without this constituent. As a result less damage is done to a paint surface which may have been superimposed. In many cases this ability to receive benefit from protective coatings because of the physical form of the rust covering further adds to the usefulness of one steel over that of another. Giving to the manganese content of a copper steel all the homage which might be due it in assisting to retard the rate of corrosion, copper may be said to be responsible to a large degree in making steel resistant to attack.

It has been the purpose of this composition to present in a small way the effect which copper has upon the corrosion of steel. To this end the simple modern conceptions of corrosion in general have been expressed and expanded into the numerous separate factors which have individual influence upon the process. Although rusting is a function of many dependent and independent variables, no effort has been made to discuss the factors singly but an overall value has been proposed as a measure of the total effect under specific conditions. Scientifically conducted experiments reveal that the presence of copper in steel lowers the rate of corrosion. However complicated be the relations which surround the application of copper steels to industrial uses, their successes endorse the correctness of the scientific tests of their durability and further serve to establish the belief that copper in small percentages has the effect of preserving the steel against corrosion.

BRIDGE DESIGN AND CONSTRUCTION

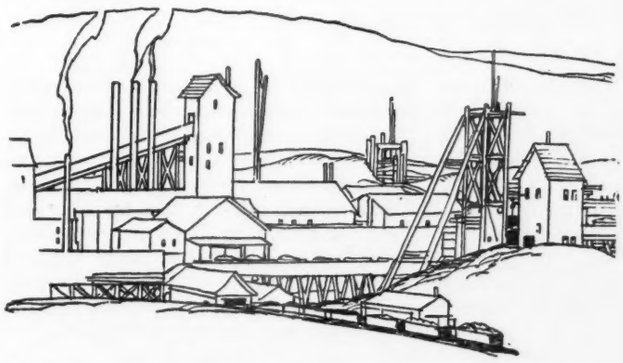
(*Continued from page 21*)

above the bed of the stream. I wanted to avoid the final artificial introduction of stresses or at least to simplify it. The span was consequently built as a three-hinged arch for dead load only. When all dead load was on and the temperature was at 60 degrees, the connecting top chord section at the center was dropped into place and the holes in the splice plates carefully marked. The member was then removed, the holes accurately drilled and the member replaced in its final position and riveted. The stress in this member is therefore zero under dead load alone and at normal temperature of 60 degrees. The trusses of course were calculated with this condition in view, namely, that they act as three-hinge frames for dead load but as two-hinge frames for live load and temperature.

At Thebes, Ill., while the bridge over the Mississippi was building, one of the pneumatic caissons was built on the bed of the river which was exposed at low water. We had the outside layer of three-inch planking all placed but not spiked when the river suddenly began to rise. It covered several feet of the planking before there was a chance to drive the spikes. But the spikes were driven. This is how it was done: A piece of gas pipe was placed over the spot where a spike was to go in, at an angle so that the upper end was out of the water. A spike was then dropped in the pipe and driven into the plank by a rod working inside of the pipe. This operation was repeated for each spike.

Of a much more serious nature was the incident which occurred at the Willamette River Bridge and which required accurate judgment and quick action. This bridge consists of four double track through spans and a long draw span, also of two plate girder spans, one at each end bridging the space between the through spans and the abutments. The piers are all of granite backed with concrete and all but one were founded on bed rock by pneumatic process. The easterly pier was located just back of a bulkhead. The rock at that point was too far below water to be reached by pneumatic foundations. In view of the pier's protected site and because the material overlying the bed rock is pure sand, it was decided to found this pier on piles. A large nest of piles was driven with an average penetration of 45 feet. The piles were then cut off below water. A special caisson was then constructed and sunk over the piles. The entire working-chamber was filled with concrete bearing directly on the piles and on the surrounding sand. The lower courses of the masonry of the pier were laid in the cofferdam formed by the upper chamber of the caisson. After the pier was completed, the 50-foot embankment with its toe resting near the pier was quickly built, but before it was quite finished a settlement of about two and one-half inches was noticed in the pier as well as a deviation from the vertical toward the embankment. This was quite alarming at first. Levels were then taken every day and the position of the pier carefully watched. In the

(*Continued on page 32*)



Metal—The Key Industry

ONE of the oldest industries is the mining of ore. Prehistoric man mined iron and copper for his weapons and utensils by hand labor. Later civilizations obtained their base and precious metals in almost the same primitive way. It is only within more recent times that explosives have been employed for mining operations.

Modern metal mining requires explosives power for the economical production of ore. This is particularly true since the fabrication of metals is a key industry. Our whole industrial structure depends largely upon the production of metals of all kinds in enormous quantities and at low cost.

For the mining of various kinds of ore, a variety of explosives are required because of the kind of ore, its formations and the conditions surrounding the operations. Large and economic ore production is dependent largely upon the selection and use of an explosive especially adapted to the type of ore desired. In the development and manufacture of explosives for the mining industry the du Pont Company has been eminently successful in producing a wide and efficient variety of explosives. For example—gelatin dynamites of 25% to 100% strength for different ores and where water is encountered; in comparatively dry mines, an ammonia dynamite has proved to be most efficient and economical; and in the "open pit" mines a "low" powder or Judson type of dynamite has been used extensively and satisfactorily.

For information regarding the selection and use of explosives for any mining operation, send your inquiries to us. Our experiences of 122 years in the explosives industry will enable us to supply the information required.

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BRIDGE DESIGN AND CONSTRUCTION

(*Continued from page 30*)

meantime, several barge-loads of rip-rap were ordered brought to the pier and dumped on its river side to counterbalance the action of the embankment. The pier stopped leaning toward the shore but kept on settling for a while though at a diminishing rate. It was evident that it would eventually reach its equilibrium. It did so after it had sunk about four inches altogether, the material on which the pier was founded having been a basaltic sand of rather low specific gravity highly saturated with water, which compressed under the combined load of the pier and of the embankment until a sufficient quantity of water was squeezed out of it to make it stable.

I think I could go on for a long time telling you of the great variety of these problems. No doubt you will be confronted with many more in your professional career and will experience the great fascination of solving them. To build an ordinary bridge over an ordinary river under ordinary conditions requires only routine training and may be done fairly well by consulting good text books, but to meet unusual problems in any branch of engineering requires something more than routine and is the real test of an engineer.

THE AUTOMATIC FUEL PROBLEM

(*Continued from page 17*)

operating load on the engine. Although increased compression ordinarily produces "fuel knock," the successful development of "anti-knock" substances within the past few years makes possible the use of very high compressions without incurring any ill effects. The percentage operating load may be increased simply by the introduction of more forward speeds of high gear ratio, actuated by suitable automatic gear selectors. In this latter practice, Europe has been somewhat ahead of us for a number of years.

In brief, then, it is entirely within reason to predict that by 1934 we shall have exhausted one-half of the petroleum available from wells. Our importations of oil will be of great magnitude. A new and important industry, that of winning oil from shale rock, will be on a firm commercial basis. Automobiles, although more than double in number, will be much more economical of fuel and as a result, the cost of operation per mile is not likely to be any greater than at present.

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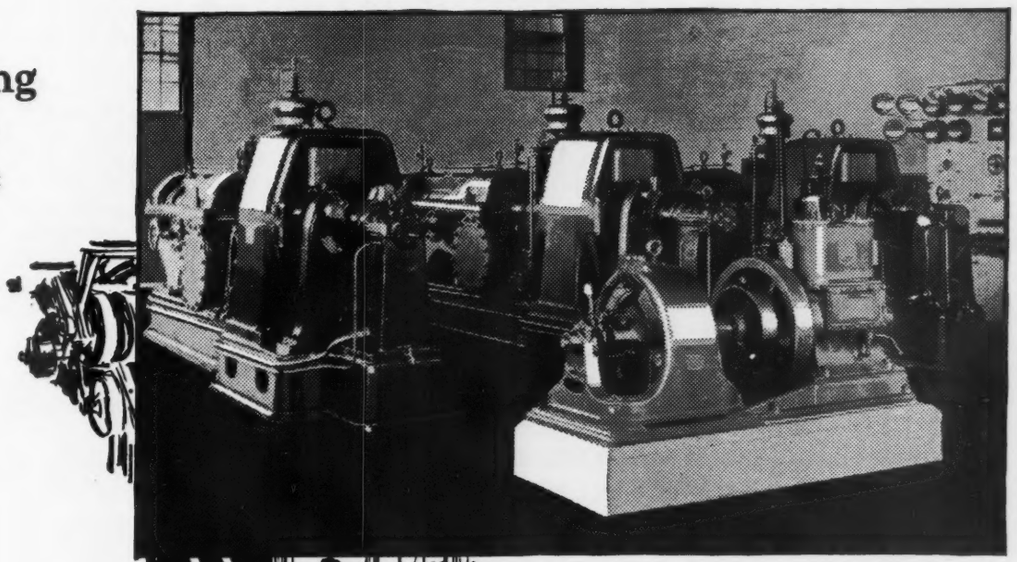

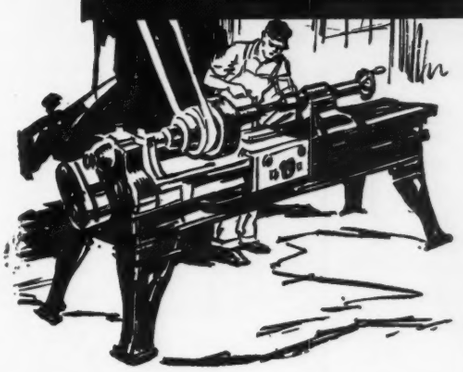

PRIOR to 1899 the works of the Westinghouse Airbrake Company was operated by reciprocating engines distributed in various parts of the plant. While this source of power was inefficient in many respects, it was the best known commercial motive force of the day.

By 1899, however, remarkable developments had been made in the design and construction of steam turbines and electric generating equipment. Called to the attention of the Airbrake officials, it was decided to give the new machines a chance, and three Westinghouse Steam Turbines were installed without delay. This was the first large installation of its kind, anywhere.

Daddy of All Large Commercial Turbines Began Operation at Wilmerding

It required *initiative* to take this step—someone had to be first. And, as in all important pioneering achievements, there was much skepticism as to results. However, the new units quickly proved their practicability. Although of only 400 K. W. capacity they proved much more efficient and economical than the old reciprocating engines. Their economy was particularly conspicuous because by careful test they showed a fuel saving of approximately 36 per cent.

Steam turbine development thus received its first real impetus in 1899, the Wilmerding, Pa., performance definitely establishing this electrical unit as a *better* method of turning the wheels of industry.

Westinghouse

ACHIEVEMENT & OPPORTUNITY

WESTINGHOUSE ELECTRIC

SALESMANSHIP

(*Continued from page 16*)

Many good sales talks are ineffective even when uniformly sustained throughout the interview, because they lack the cumulative feature; they should grow stronger as they proceed, and conclude strong in earnest summing up.

Theaters are packed at $1.50 to $5 an auditor to see and hear a great actor. Suppose instead of inflicting the usual sales talk of the average salesman upon the indulgent buyer, the latter had to pay the price of $10 an interview for the privilege of enjoying and benefiting from the sales demonstration of the average salesman. How many salesmen would ever get a second interview with the same prospect? How many would merge the alpha and omega of their sales performance into one brief experience, and among those who survived, what a great improvement over present methods would be demanded!

Sales talks should be written out, even if not memorized. The muscular and nervous activities, "hand and speech are physiologically connected." Nothing so stimulates thought and constructive imagination as the habit of writing; it aids accuracy, stimulates the association of ideas, and develops expression. But few of us make an effort to think and to think our best, and until we do the best of us is dormant, because as Hamilton says, "The larger part of our mental riches are hidden away in the obscure recesses of the mind."

This article is intended to be more suggestive than exhaustive, and somewhat constructive in criticism, and I shall therefore close it with another encouraging quotation from William Hanna Thompson's "Brain and Personality":

"Personality is modified mind stuff or original substance which constitutes the basis of individuality."

SCIENTIFIC MIND

(*Continued from page 5*)

all-round man, the one who may be considered the ideal in industry, in home life, and spiritually, is the one whose knowledge comprises two educations, namely the cultural and the scientific.

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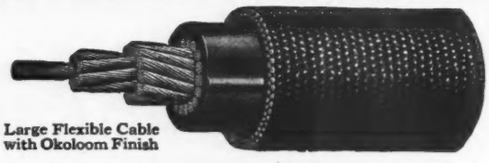

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The result is a weave similar to that on fire hose, and gives a splendid mechanical protection to the insulation. Its use is recommended in any service where heavy abrasive conditions are encountered.

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OKOLOOM CORD—a combination of Okonite Flexible Reinforced Cord with Okoloom covering—is by far the best Flexible Cord produced, combining as it does the durability, life and high electrical properties of Okonite, with the perfect mechanical protection of Okoloom.

It is specially adapted for use where hard service is required such as portable connections in mines, docks, railway shops, etc. In short, any place where the cable is constantly dragged over the ground.

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THOUGHTS ON ENGINEERING EDUCATION

(*Continued from page 7*)

instructors and requiring these to take a year off, from time to time, to return to industry. Such experienced men, however, are not attracted by the small salaries paid to instructors in engineering colleges. A higher rate of remuneration would do much to raise the quality of the teaching staff. In some colleges provision is made to allow instructors to carry on professional work during the college year. Frequently the instructor has no graduate training and has been acquainted only with the methods and system of his own college. This is a serious defect, but one that might be remedied by the colleges themselves. Instructors are said to have been interchanged, from time to time, in certain western universities for a period of a year or so. The idea is a splendid one which might be extended in our eastern technical schools, even to the leading professors. We have interchange of professors with France. Why not interchange with one another? Visiting professors and instructors would see how problems are met in other colleges, while the colleges visited would benefit by having courses presented from a new outside viewpoint, to the general good of all concerned. The scheme has been tried with splendid results, and it deserves much wider application than heretofore.

In these rambling paragraphs, the writer has suggested some of the problems confronting the leading schools for training engineers. It would seem that broader training and therefore longer courses are desired, that engineering be made a professional study, that only the best men be encouraged to stay in these advanced courses, and that some attention be given to the further development of instructors and professors.

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SUBMARINE SIGNALLING

(*Continued from page 11*)

small a difference as .00001 second will be noted.

Manifestly it is not convenient for an observer to place his head in the water, so, in the simplest form of binaural apparatus for submarine listening, sound is conducted by tubes from the water to each ear. Two hollow rubber balls are mounted on the ends of two long metal tubes, which are fastened side by side, and two feet from their lower ends are bent out at right angles, so that the apparatus is in the shape of an inverted T with the rubber balls four feet apart. The upper ends of the pipes are connected to a stethoscope so that the left ear is connected to one rubber ball and the right ear to the other.

Sound waves coming through the water compress the rubber balls which compress the air inside them, and the changes in pressure are communicated by the air in the tubes to the observer's ears.

The apparatus is hung overboard from a boat and the listener turns it until the sound "centers" or appears to be dead ahead in his head. It is a very peculiar effect, the sound seeming to wander from left to right in the head and vice versa according to the direction in which the tubes are turned.

When the sound is "centered" its direction is perpendicular to the base line joining the two rubber balls.

This listening device during the war was used on submarine chasers and also on submarines, by providing suitable means for bringing the tubes through the hull with a water-tight connection that would permit rotating the apparatus.

A later development of the binaural system consists of using microphones in place of the rubber balls, having the microphones mounted on a fixed base instead of a rotating one and using a "compensator" to center the sound.

The regular submarine microphone was found not to be suited for binaural work on account of its resonance, and a special microphone having an aperiodic rubber diaphragm was invented and perfected.

The compensator consists of two aperiodic telephone receivers connected to air paths whose lengths from the receivers to the observer's ears can be relatively varied by turning a hand-wheel. The telephone receivers are each connected to a rubber diaphragm microphone. The times of arrival of the sound at each ear can be regulated according to the length of the air paths. The observer turns the compensator hand-wheel until the sound appears to be "centered" in his head and then reads the direction in degrees from a dial which is calibrated and turns with the the hand-wheel.

The rubber diaphragm microphones are more sensitive than the rubber balls and excellent results have been obtained with this apparatus. The "drifter set" is one form of this listening device which was used extensively by submarine chasers. It consists of three rubber diaphragm microphones mounted on a triangular frame sus-

(*Continued on page 38*)

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INDUSTRIAL BUILDINGS SHOULD BE WELL LIGHTED.

From the employer's viewpoint, the big difference between men who work out of doors and those who perform tasks inside the building, is the factor of light. Daylight furnishes sufficient illumination outside during the daytime working hours for men to pursue their tasks efficiently and safely. But the proposition of getting enough daylight into the interior of industrial buildings, requires some thought.

It is not a difficult problem by any means, and any employer can take advantage of daylight and utilize it for lighting his building during the daytime, if he desires. It is an excellent light, especially suitable for the eyes, reducing eye strain and eye weariness to a minimum, and has the great economic advantage of costing nothing.

To utilize daylight to the utmost, we must first provide means for allowing daylight rays to enter the interior of buildings in sufficient quantity—namely, proper and adequate windows and skylights. Many excellent instances of buildings designed with a due regard to the importance of daylight lighting can now be seen in many of our industrial cities. Such buildings present the appearance of being practically all windows—"window walled," as they are termed—and this type of daylight construction is coming rapidly into favor, because it constitutes a more healthy building for large numbers of employes, both from the lighting and ventilation standpoints.

Among those who have constructed this type of modern industrial building may be mentioned: The Shredded Wheat Co., Gillette Safety Razor Co., Lyon & Healy Piano Co., H. J. Heinz Co., Corona Typewriter Co., Skinners Macaroni Co., Grape Juice Co., Dodge Bros., Nelson Valve Co., Piston Ring Co., Remington Arms Co., and a great many others.

The Larkin Co., Philadelphia, has erected a building almost entirely glass, 85% being windows, and the Loomis Breaker, operated by the D. L. & W. R. R. Co., Nanticoke, Pa., is literally a glass house, being 93.5% of glass. The new buildings of the Winchester Repeating Arms Co. have an average glass area of 58%.

An investigation covering 18 buildings constructed by the Aberthaw Const. Co., Boston, shows that the average window area is 57.5%.

These figures indicate how important the subject of lighting is now considered by employers of industrial labor, and how well the idea has been carried out by the architects and engineers, in order that all parts of a building may receive sufficient daylight. But, in addition to providing ample window space, there is another factor which is equally important, and that is, equipping the windows with the proper glass.

The bright direct rays of the sun should not be permitted to strike the eye, and we must provide a means for reducing the glare to rays which will not be too bright. This is accomplished by glass especially manufactured for industrial windows, known as Factrolite. This glass possesses the property of breaking up the intense rays of the sun and diffusing the light into the interior of the building in proper portions, solving the problem of sun glare.

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SUBMARINE SIGNALLING

(*Continued from page 36*)

pended from a float, which as the submarine chaser drifts along, trails away from it. The sides of the triangular frame are base lines between the microphones. A cable leads from the microphones to a compensator on board. Switches in the compensator permit using the microphones at the ends of any one of the three base lines, and thus three readings can be made which check.

The apparatus described above could not be used with the listening ship under way and was therefore not adopted for use on a destroyer. For destroyers was developed what is called the "multi-spot" system. This system is too elaborate to fully describe in this article. In brief, it consists of a number of receiving devices which are placed in a line on each side of the destroyer at the bow and near the keel.

In one type of the "multi-spot" the receiving devices are rubber nipples on the ends of tubes of various lengths which are connected to an acoustic compensator.

In another type the receiving devices are rubber diaphragm microphones which are connected to an electric compensator in which the sounds are compensated by lagging electrically the currents from the microphones.

The idea of the multi-spot system is to make the apparatus most sensitive to sounds coming from the direction it is compensated for. In this manner many of the disturbing noises on the listening vessel are eliminated and the propeller sounds of the submarine made louder and clearer.

This apparatus is also very useful for listening to the propeller noises of surface craft, determining their direction and thus avoiding collision in time of fog. It can also be used for listening to submarine bells and oscillators and their direction may be determined without swinging the ship.

Audion amplifiers have a use in submarine signalling as well as for radio. When placed in the telephone circuit, the intensity of the sound can be increased any desired amount.

An important use of submarine signals is in the determination of distance. This is accomplished by having the sending station send out simultaneously radio and submarine signals. The receiving station on hearing the radio signal starts a clock in motion, whose dial is marked in yards, and stops the clock when the submarine signal is heard. The radio wave being nearly instantaneous in its reception while the submarine wave travels at 4,800 feet a second, a considerable period of time elapses between the arrival of the two signals even for short distances. Thus the personal error in starting and stopping the clock is very small and quite accurate measurements of distance may be easily obtained.

Still another use of submarine signals is in determining the depth of the water or sounding. A vessel equipped with an oscillator sends out a signal and the echo from the bottom is heard. The time between the sending of the signal and the receiving of the echo is a function of the depth of the water. With a suitable instrument for measuring this time, the depth is known.

Submarine signalling, therefore, has become firmly established and has proved itself of great service in peace as well as in war. As it is yet in its infancy, who knows what developments the future may have in store?

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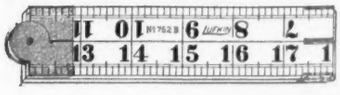

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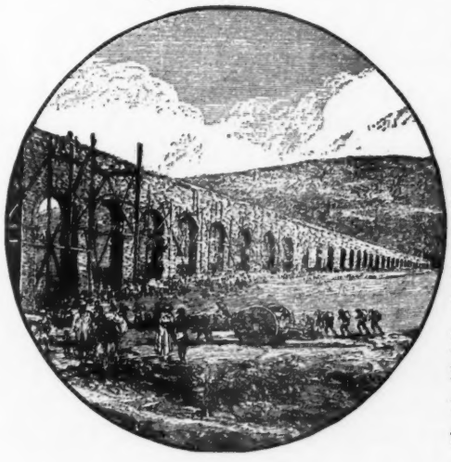

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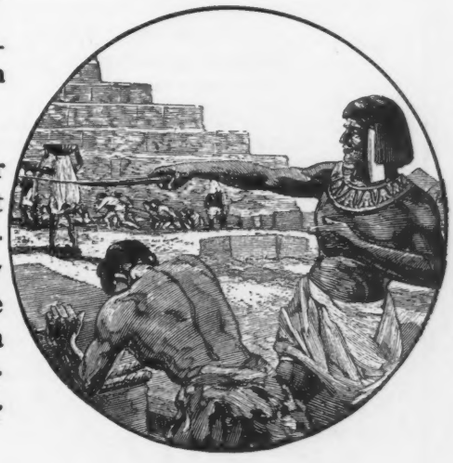

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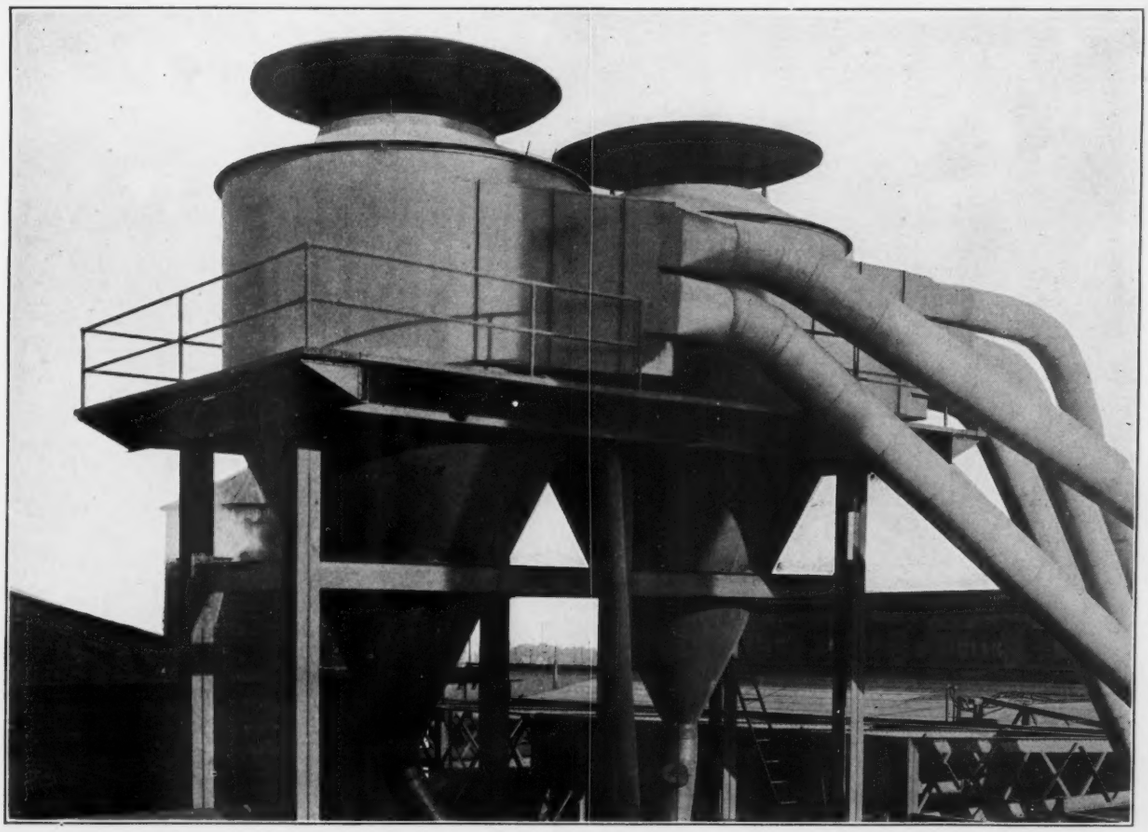

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Without the waste collectors the machines would have to be stopped every so often to be cleaned. Conservatively estimated, this would mean a reduction in production of 15%. Further, the waste material is so effectively removed that it is reflected in fire insurance premiums as well as in accident prevention. It would be impossible to operate an efficient and safe wood working plant without such equipment as Sturtevant have provided us with here. In our long acquaintance with the equipment, our experience has been that it is always satisfactory in every way."

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